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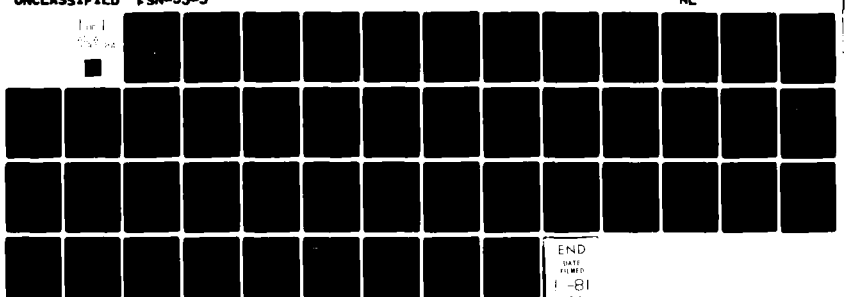

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the scientific staffs of the United States Air Force's European Office of Aerospace

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I. Kaufman and Victoria S. Hewitson

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COMPUTER SCIENCE

FOURTH INTERNATIONAL SYMPOSIUM ON MODELLING AND PERFORMANCE EVALUATION OF COMPUTER SYSTEMS

This Symposium on Modelling and Performance Evaluation of Computer Systems, held in Vienna, Austria, 6-8 February 1979 was sponsored by the International Institute for Applied Systems Analysis (IIASA). It was an important conference, the papers demonstrating that the subjects of simulation and modelling are coming increasingly under control through the application of computers, and understandably, that computer performance evaluation is one of the first areas to benefit therefrom.

This report will start with a brief description of IIASA, and will then review some of the more important papers. The conference presented papers on modelling methodology, on queueing network analysis, applied performance analysis, scheduling techniques, performance control, and communication network modelling.

Although the US and USSR are the two major sponsors of IIASA and many Russians were in attendance, they confined their disclosures to one paper written jointly with a French scientist. The primary revelations were American (12 papers from the US, two from Canada), French and German (six papers each). Hungary offered three papers, of which one was an invited tutorial. Israel and the Republic of South Africa offered two each. (It is worth noting that the Univ. of Stellenbosch, RSA, is doing important seminal work in Queueing Network Theory and Analysis.) Five countries presented one paper each, of which only one, an invited tutorial from Poland, came from a non-Western country.

IIASA is jointly sponsored by the National Academies of Science of 17 countries, of whom the largest and most influential are the US and the USSR. The Institute regards itself as non-government and its Director, Dr. Roger Levien, an American, asserts that its scientists, when they come to IIASA, represent only themselves. IIASA's funding is $10 million per year, and its staff includes 95 scientists from 20 different countries. IIASA's prime objective is international collaboration for the advancement of science (and the "craft" of system analysis) in its application to problems of international importance. These may be global problems, which inherently involve more than one nation, or universal problems, which may occur within one nation but have implications for others.

IIASA's scientific staff includes specialists in the following fields: Environment, Urban Health, Management Technology, and System and Decision Science. There are departments for Computer Science, Decision Science, and Computer Services. Primarily attention is placed upon problems of Food, Energy, and the Environment. In support of this activity, the Computer Science Department under Prof. Aleksandr Ivtrimenko is particularly involved in networking and artificial intelligence. The Computer Services Department has a PDP 11/70 operating under the UNIX Time Sharing Operating System, and efforts are underway to link this computer into two networks, one in Western Europe involving France and Italy and one in Eastern Europe, involving Hungary and Poland and Russia. (For additional information on IIASA see Blachman *ESN* 32-2:51.)

Details of Individual Papers—There were several papers presented by representatives of IBM dealing with methods for performance evaluation of computer systems through the use of models.

Martin Kienzle and Kenneth Sevcik [IBM Yorktown Heights, NY, (Sevcik is now at the Univ. of Toronto)] presented a procedure that attempts to integrate several approaches to system modelling. They first construct what they call a "Measurement Model," derived from actual measurable variables available in the real life system. These are variables that can actually be recorded by hardware or software monitors. By combining the "Measurement Model" with estimated parameters they next build a "System Model," which provides a logical description of the components that influence the system's performance. Next they map parameters derived from the detailed input parameters of a Computational "Queueing Network Model" (QNM). These QNMs are then used to predict the effect on performance of changes in configuration software, or workload. Configuration changes can include a hardware upgrade or additions. The paper described the development of the QNM, going through design, validation, and use of the model for prediction of system performance.

A case study, applying the method to an IBM 370/165 Mod II operating under the OS/VS2 operating system MVS at the Univ. of Toronto, showed how the modelling procedure improved the formality of the parameter transformation from measurement data to QNM input parameters, made modelling decisions more explicit, and made the influence of different parts of the system more visible as they affect performance.

Next, Martin Reiser [IBM Yorktown Heights (now at IBM Zurich)] and Yonathan Bard (IBM Cambridge, MA) each offered a paper on extensions of QNMs. Reiser's paper presented methods of mean value analysis (MVA) which simplify the manipulation required so that the modelling techniques may be applied to communications systems with up to hundreds of queueing chains. Bard carried MVA techniques further and indicated that much work has already been done to apply MVA and QNM techniques to the IBM VM/370 computer.

Prof. Ulrich Herzog (Univ. of Erlangen, Nuremberg, FRG), a former IBM Fellow at Yorktown Heights, spoke of the problems involved in modelling a hierarchically organized multiprocessor system. At Erlangen he now has a two-level system (the Erlangen General Purpose Array, or EGPA) operational, which will be expanded to three levels: one master control machine at the top of the hierarchy, second-level machines to implement the operating system(s), and processors at the third level to handle application programs. He described the models in the three-level case and acknowledged that these models will not be validated for at least another year, since there will not be an experimental three-level network until then. He concluded with a summary of outstanding problems yet to be solved (i.e., not yet incorporated in his models): signaling overhead, multiple CPU-IO overlap, priorities, and data transfers.

Dr. William Stewart (formerly of Rennes, France, and now at North Carolina State Univ.) described a direct numerical solution method for analyzing ANMs that is very economical in computation requirements and that yields early indications of rounding error. Resource requirements for computation increase only linearly with the number of users. In a case study shown, Stewart demonstrated that he achieved more accurate results in a shorter time than by using an iterative method. However, memory requirements were greater.

Dr. D. Asztalos (Computer Center of the Hungarian Planning Office, Budapest) described a technique combining a simulation model and a QNM analysis which he therefore called "hybrid." A trace-driven simulation model (i.e., a simulation model whose input is derived from the real life system under study) is combined with a closed QNM with two servers to evaluate the different possible job scheduling algorithms. Such evaluation could not be done on the actual system without great risk of disrupting operations. Furthermore, scheduling algortihms more complicated than First Come First Served (FCFS) could not be modelled analytically. The operational system which Asztalos modelled is a batch mode ICL 4/70, a medium scale machine of not too recent British design. The model was calibrated and validated, and the author claims that very little work has been reported on model validation—a convincing assertion, in view of the many papers at this conference that described models not yet validated. Asztalos claims that such hybrid simulation analytical models are today the only tools by which sophisticated schedulers of modern complex computer systems can be modelled and evaluated.

Prof. Jacek Blazewicz (Institute of Control Engineering of the Technical Univ. of Poznan, Poland) presented a tutorial on techniques for developing and evaluating scheduling algorithms under resource constraints. He progressed from the case of a deterministic model under strong assumptions (i.e., where many factors are known a priori: the number of tasks, arrival times of tasks, and resource requirements, and where the number of tasks is finite and there is no possibility of system performance failure owing to deadlock) to a similar model under weak assumptions (i.e., where none of the above are true). He indicated that the strong assumption case can usually be solved, and the results can only suggest options to try in the weak assumption case.

Dr. Manfred Ruschitzka (an Austrian now in the Department of Computer Science at Rutgers Univ., NJ) presented and successfully defended a scheduling algorithm for processor sharing which he calls the Common Service Ratio (CSR) algorithm. He compared the CSR algorithm

to several processor-sharing algorithms: the Round Robin (RR); the pre-emptive Last Come First Served (LCFS); the non-preemptive Highest Response Ratio Next (HRN); the Shortest Job First (SJF); and the First Come First Served (FCFS). Ruschitzka claimed that to implement a policy of equitable sharing, the CSR algorithm is superior to the others. In CSR the priority of a job is determined by the ratio of the time it must take and its attained service. CSR is load sensitive, with long jobs served but discriminated against under high load conditions, but increasingly favored as the load decreases. This algorithm, says Ruschitzka, is especially promising in communications applications.

Dr. Andras Benczur (Director of the Department of Statistics of the Computer and Automation Institute of the Hungarian Academy of Science) presented an invited tutorial on Method for Providing Data Base Integrity. He felt that the following three groups of people are most influential in this field: K.M. Chandy of IBM US and his colleagues; Prof. E. Gelenbe of Univ. of Paris-South and his colleagues; and Benczur and Kramli and their colleagues in Budapest.

After his general description he discussed his own work, discussing strategies for achieving economical system recovery under certain failure patterns. Unfortunately, his highly equation-oriented presentation defies the ability of this writer, at least, to present a meaningful narrative precis. Copies of his paper can be made available to those readers hardy and interested enough. Benczur did acknowledge that his work has not been extended to distributed data bases, and that he believes it will be very difficult to do so. Gelenbe observed that one of his colleagues (Bouchet) has done so.

Prof. A.E. Krzesinski (Univ. of Stellenbosch, South Africa) has been applying Queueing Network Analysis (QNA) to a variety of problems ranging from the hypothetical to the most applied. A review of the bibliographies offered at this conference indicate that, like Chandry, Gelenbe, and Benczur, Krzesinski is an often cited reference to workers in the field of QNA. He has applied QNA to the Operating System of several computers.

In his paper at this conference, he and his colleagues presented a queueing analysis of a dispatcher model associated with the Univac 1110 EXEC-8. The dispatcher is part of a control system called the R-MPA (Reference-Model Parameter Adaptive) system which is being developed at Stellenbosch to monitor workload processing and to adjust the operating system to respond optimally to changes in workload. The total R-MPA consists of three hierarchically independent models of the 1110: two detailed analytical models—the CPU dispatcher, and the CUP memory allocator—as well as an overall system performance model.

In a private conversation Krzeskinski said that he is involved in two main activities. The more general is consulting with South African industry, helping to solve computer performance problems through the application of QNA. The other is an analysis of a nationwide banking network that has been built without much design trade-off study because it was felt that the available processing resources far exceeded the requirements. Since the requirements are now growing rapidly, Krzesinski has been asked to apply QNA to predict future performance as traffic and workload further increase.

Mr. Tzelnic (the Technion of Haifa, Israel) presented a paper authored together with M. Hofri derived in part from Tzelnic's PhD thesis. Highly mathematical, this paper dealt rigorously with the problem in memory management of optimizing the page replacement algorithm (PRA) in a paged virtual memory system. Tzelnic uses a Markov Replacement Module, a probabilistic law defined by a stochastic matrix. He claimed to extend work done separately by Gelenbe and Denning. In fact, he demonstrated that Denning's intuitive law of replacement is a special case of his formulae. Discussion later expressed doubt about the adequacy of the Markov model for describing program behavior.

Prof. Edward Lazowska (Univ. of Washington) and Prof. Clifford Addison (Univ. of Toronto) dealt with the practical problem of how to select parameter values to model service time distribution. Lazowska felt that there are many cases in which mean value analysis is not sufficient, and he presented a technique for achieving increased accuracy by selecting parameter values for service time distribution instead of the moments of this distribution. He presented a parameter solution procedure that is computationally efficient and described some experimental results.

Drs. M. Badel and J. Leroudier (Institut de Recherche d'Informatique et d'Automatique, Rocquencourt, France) presented an invited paper describing techniques for examining the performance improvement obtained by the addition of cache memory to a minicomputer, the MITRA 125 of French design and manufacture. They have obtained results which indicate that a large cache (10K words or more) is required to achieve substantial improvement, but that, with reasonable trade-offs, a tripling of performance effectiveness is possible.

Ms Astrid Geck (Univ. of Karlsruhe, FRG) described methods of modifying the operating system of the University's Burroughs B6700 to permit both the degree of multiprogramming and the intensity of memory usage to adapt dynamically to configuration and load. A controller using feedback information was incorporated into the operating system, Burroughs' master control program MCP release 2.8.

Based upon this Symposium only (the first on research in computer performance evaluation attended by the writer), it is striking how very much work in this field is being done in the US in general and by IBM in particular. A large number of the speakers, and even those in European universities, have spent formative periods working at IBM. This is perhaps instantly understandable in view of IBM's dominance of the large computer world. However, it is clear that Gelenbe in France, Beilner and Herzog in Germany, and various people in Eastern Europe (Arato and Benczur in Hungary; Blazewicz in Poland) and Krzesinski in South Africa are also doing very important work, and that in France, at least, the work has important implications for future application to distributed systems.

At this conference Hungary and Poland, as neighbor states of Austria, had respectable participation. It was regrettable that there was not a proportional representation by Russian and East German scientists, who most assuredly are also active in this field. [George M. Sokol, Information Services Branch, U.S. Army Research and Standardization Group (Europe)]

EARTH/OCEAN SCIENCES

MICROMETEOROLOGY AT THE FREE UNIVERSITY OF AMSTERDAM

The Free University at Amsterdam has an interesting history. At the time it accepted its first students, in 1880, "orthodox" Protestants, who were members of the Calvinist movement, met with discrimination from the state and the established Dutch Reformed Church. For example, they were not allowed to teach in state universities. The Free University was founded by a Dutch Calvinist theologian and politician, Abraham Kuyper, for the purpose of establishing a university that was "free" from the influence of the government and the Dutch Reformed Church. The student body had grown to about 1000 students in 1947 when the Dutch government began to grant it partial support. At that time three fourths of the students were from Calvinistic backgrounds.

The next three decades brought tremendous changes to the University. The government subsidy grew to 100%, the student body grew to almost 12,000, almost equally divided between members of the Dutch Reformed Church, Catholics, Calvinists, and non-denominational students. By 1963 it was scattered throughout 30 buildings, all over Amsterdam. By 1973 it had moved to a new 45-acre site in south Amsterdam, only 15 minutes from the town center by public transportation. Its main building is now the largest in Amsterdam. It is now considered on a par with state universities in the Netherlands and enjoys the same privileges. However, it still maintains some of its original individual character. The state allows much of the control to remain in the hands of the original religious board that was set up to establish the University. All the professors and some of the officials are still appointed by the Board.

I had written to the Free University to arrange to visit with Prof. P. Groen, who was head of the combined Department of Oceanography and other earth sciences. The reply came back from a Dr. Hans F. Vugts, welcoming me and stating that Prof. Groen had retired and that the writer would be in charge when I came.

Vugts and his two colleagues turned out to be boundary layer meteorologists doing work which is fascinating to me. They have several lively research programs under way and are being assisted by Prof. H. Tennekes, Director of Scientific Research at the Royal Netherlands Meteorological Institute in De Bilt. Tennekes, who regularly teaches a class at the Free University, is well known in the US for the research in turbulence he did while on the staff of Pennsylvania State University.

Vugts, Dr. F. Cannemijer, and Mr. A. Lusink are working on three projects. The first of these is a study of changes in mean flow and turbulence structure as air moves inland from the sea. Here an experiment that will involve the response of the atmospheric boundary layer to changing surface conditions both over the ocean and over the land is to take place during May and June 1979 on the island of Schiermonnikoog, off the northern coast of the Netherlands. Previous studies in the area have shown the island's beach to be extremely aerodynamically smooth. Thus the experiment will provide data on the boundary layer response to changes in heat flux caused only by differential heating and cooling between land and sea. The data set will be of importance in increasing our understanding of the land-sea-breeze system. The experiment is a combined experiment with Dr. N. Bush and his group from the Risø Research Laboratory in Denmark. It will be using a row of fixed instrumental masts that are perpendicular to the beach. The first 10 m mast will be placed 500 m seaward from the beach. It will be instrumented with two cup anemometers, three air temperature sensors, a water temperature sensor and a test gauge. The next 10-m mast will be at the low water line, with three air temperature sensors and three anemometers. Four 20-m masts (I, II, III,IV) will be located at the high tide level and 80 m, 190 m and 250 m inland from the high tide level. Each tower will have six air temperature sensors. Towers I and III will also have six anemometers. Turbulence measurements will be carried out with three-dimensional sonic anemometers, a bivane and a three-dimensional hot wire-cold wire system.

Bush's group will also be using Doppler radar to measure small scale fluctuations in the wind. This research is being partially sponsored by a grant from the NATO Air-Sea Interaction Committee.

A second project concerns the heat balance of tidal flats in the Wadden Sea between the north coast of the Netherlands and the offshore fringing West Frisian Islands that form the north and western boundaries to the Wadden Sea. This study is being done in cooperation with Dr. J.T.F. Zimmerman of the Netherlands Marine Research Institute on Texel Island, the westernmost of the West Frisian Islands. It is partially supported by ZWO, the Dutch equivalent of the US National Science Foundation.

The third project is the study of the microclimate of coastal sand dunes. An experiment is scheduled for September 1979, when Dutch Air Force planes will make a 24-hour series of infrared pictures to determine the time-dependent temperature distribution of the surface of the dunes. At the same time Vugts' group will be taking ground truth temperature observations of dunes and carrying out other microclimatological observations on the slopes and exposed vegetation on the dunes.

The goal of this investigation is to determine the relationship between meso and microclimatological conditions in the dune area. Radiation, air humidity, and wind will be measured over the dunes. Temperature will be observed above, at, and below the air soil interface. Vugts has carried out research on a wide variety of micrometeorological problems. These include: the development of an accurate method of predicting temperature variations in small mountain streams by using an energy budget method involving meteorological parameters; a study of the relationships between wind speed and stability and the aeronautic behavior of spiders; air mass modification owing to a step change in surface temperature; and the interaction between the semidiurnal lunar tide and the daily variation of solar radiation over a tidal flat. (Wayne V. Burt)

PHYSICAL OCEANOGRAPHY IN PARIS

The Laboratoire d'Oceanographie Physique du Muséum National d'Histoire Naturelle has, by a wide margin, the largest research program in physical oceanography and air-sea interaction in France, with 18 researchers and 27 technicians, instrument engineers, and other supporting personnel. It is located on one edge of the Jardin des Plantes, one of the largest public parks in Paris containing a large botanical garden. The origins of the museum and garden date back to King Louis XIII who, around 1620, established the garden as a primitive agriculture research station for the purpose of improving strains of food producing plants.

The Oceanographic Laboratory is ideally sited across the street from the new Pierre and Marie Curie Campus of the Univ. of Paris. Some of the staff teach classes at the University and carry out cooperative research and instruction programs with physical and chemical oceanography programs there. The physical oceanographic laboratory was formally established in 1955. Prof. H. Lacombe, its very energetic director, has worked at the Museum since then.

A discussion of funding of the operations of the Laboratory had a familiar ring, in that it is funded in much the same manner as the larger oceanographic laboratories in universities in the United States. A small percentage of support comes from the Museum, the parent organization, while the rest is "soft money" coming from various governmental organizations. About a quarter of the latter comes from CNRS, the National Center for Scientific Research, a counterpart to our National Science Foundation. Over half of the Laboratory's support and the ships it uses come from CNEXO, the National Center for Exploitation of the Oceans, which is under the Ministry of Industry. Although CNEXO has a small group working in physical oceanography, one of its executives stated that the Laboratory of Physical Oceanography at the Museum acts as the physical oceanography branch of CNEXO. Some of the research at the Museum supported by CNEXO has direct relevance to the solution of applied problems such as the siting of atomic power plants.

The Laboratory of Physical Oceanography of the Museum has two basic themes in its research program: To study the response of the ocean to atmospheric forcing, and to develop and verify fluid dynamic models of the ocean. The research program is divided into four divisions, each with a division head.

The Turbulence Division is under the direction of Maxence Revault d'Allonnes, one of the two assistant directors of the Laboratory. The group is working on the very difficult fundamental problem of determining experimentally the fractions of wind energy that are transferred to the oceans to generate waves, create currents, and mix or stir the water column and change the vertical distribution of potential energy and temperature in the ocean.

During October 1976, the Turbulence Division made a major series of fixed-point measurements from a manned anchored buoy. The buoy, BORHA II, belonging to CNEXO, was anchored in deep water, 80 miles southwest of Marseille. A three-point taut mooring was used to increase the stability of the buoy. Several complex precision measurement systems were installed on the buoy for simultaneously measuring the energy influx from the wind, the energy distribution in surface waves and horizontal currents, and vertical mixing in near-surface waters.

The wind friction at the ocean surface was determined by three independent ways: inertial dissipation method, average wind profiles, and direct correlation method. The amplitude, spectral energy density, and the phase speed and direction of propagation of different wave components were monitored with wire capacitance sensors.

A "bathyprobe" and thermistor chain were used to measure the vertical distribution of water currents and temperature down to a depth of 25 m. A complex apparatus consisting of a fixed array of tiny propellor current meters and hot film devices was used for fine measurements of current and temperature gradients, of their evolution in time, and of the vertical turbulent flows of quantities of heat and movement associated with these variations.

Results obtained so far show that dynamic turbulence in the near-surface mixed layer is extremely intermittent and limited to small pockets some tens of meters in size. The spectrum of turbulence is rather narrow, from 1-40 Hz.

The approach taken was to determine the relative proportion of energy from the wind that went into surface

waves, horizontal currents, and vertical mixing from the time evolution of these parameters during a very strong gust of wind. An approximate balance was calculated from the difference between the initial state, before the beginning of the gust, and the final state, when the wind was steady after the gust. The time dependence of the measured current down to a depth of 20 m was found, and from this the time and space (vertical) scales of penetration linked to the surface wind were determined. The effects of a strong gust reached a depth of 20 m in 8 hours in a very weak thermal stratification of less than 0.02°C/m.

The Division is in the final stages of analysis of these data. Unfortunately the experiment cannot be repeated in the foreseeable future because the CNEXO buoy has been decommissioned.

The Formation of Water Types Division, headed by Jean-Claude Gascard, has been studying the formation of bottom water in the northwestern corner of the Mediterranean Sea for about 10 years. About 36,000 km^3 are formed in almost exactly the same place each winter. This is the original source region for the distinct Mediterranean water-type of deep water that is widespread in the Atlantic Ocean. Both British and US scientists have cooperated in this program from time to time.

Gascard has recently expanded his program to include a cooperative program with Dr. George Needler of the Canadian Bedford Institute at Dartmouth, Nova Scotia. The mechanisms involved in the formation of deep water in the Labrador Sea that they are studying appear to be similar and of the same scale as those responsible for the formation of bottom water in the northeastern Mediterranean Sea. They also hope to expand their studies to include the processes involved in the formation of surface and intermediate water types.

In the Mediterranean Sea, a divergent cyclonic eddy forms in winter with a diameter of about 100 km. It is called the Medoc Eddy, after an international group that studied it in 1969 and during the early 1970s. The horizontal divergence in the Eddy brings high salinity water to, or near the surface. Small secondary eddies about 10-km wide then form around the edges of the 100-km eddy.

The region is subject to the mistral and tramontane, violent driving cold winds that blow over the eddy system. The strong cooling and evaporation at the water surface cause a rapid increase in the density of the salty surface waters of the eddy system. The combination of increased density of the surface waters and mechanical stirring by wind causes a rapid overturning in the water column. When the winds are sufficiently strong and blow long enough, the stirring will extend to the bottom. The overturning and formation of bottom water is an intermittent or batch type of process that occurs most often when peaks in the wind speed occur.

If the following conditions are met, bottom water is formed: the large cyclonic vortex is present; there is an intermediate layer of warm and salty water at mid depth; and meteorological forcing creates intense evaporation at the surface. This explains why there are only a very few places in the oceans where deep and bottom water types are formed.

Gascard compares the formation of the small 10-km oceanic eddies to the formation of baroclinic-instability-induced highs and lows in the atmosphere in the region of the polar front. The ratio of characteristic scales of velocity and length in the oceanic eddies and the atmospheric highs and lows is approximately one to one hundred.

The Climatic Atlas Division is headed by Dr. Joseph Conella, who is well known to physical oceanographers in the US for his extensive work on inertial oscillations in the oceans and near-surface currents. For much of his research he used the CNEXO manned anchored buoy. Now that this research platform is no longer available, he has completely changed the direction of his research, and is now working on a climatological atlas of the Mediterranean Sea. The atlas is based on Nansen bottle casts. All historical oceanographic data for the Mediterranean Sea is on file in the computer of BNDO, the French National Oceanographic Data Center that is part of the CNEXO Center at Brest. Conella has a console at the Museum in Paris with a direct data link to the BNDO computer data bank. The projected atlas is scheduled for completion by the end of 1980.

Both Lacombe and Conella emphasized the great difficulty they are having in validating the individual data points. In many cases the temperature difference from the surface to the bottom is less than 1°C. Conella feels that he requires

temperatures to an accuracy of 0.01°C. He is using French, American, English, Italian, Russian, Greek, and German data and is having a very difficult time deciding which are good and which must be discarded.

His group is also doing an intensive study of sea surface temperature (SST) in the Mediterranean. Anomalies occur in the SST in the Mediterranean Sea in the same manner as in the Pacific, Atlantic, and Indian Oceans. Gonella feels that SST anomalies are a better indicator of climatic changes and variations than are air temperatures.

The fourth research division is concerned with Mathematical Modeling, and is headed by Michel Crepon. He described a model of the Gulf of Lyon in the northwest corner of the Mediterranean Sea. The strong winds of the mistral sweep over the area causing patches of strong highly transient upwelling. As air is nearly cloud free when the mistral blows, very high quality infrared satellite imagery gives excellent surface temperature maps. These photos delineate the upwelling areas with high precision. Crepon and one of his students have developed an interesting model which takes into account every twist and turn of the coastline. The grid is composed of different size triangles. Large triangles are used away from shore, with the size decreasing in a shoreward direction where coastal topography is important and where the upwelling patches occur.

Crepon is studying the thermal forcing of the Atlantic. His model shows that the thermal forcing is the same order of magnitude as the wind forcing.

He is also working with some meteorologists on a model of the atmosphere using a seasonal time scale and taking into account feedback from the ocean. He is endeavoring to study variability over a ten-year period. Other models include the prediction of oscillating currents in the oceans from winds only and of near-shore Kelvin waves.

In summary, the Physical Oceanographic Laboratory of the Paris Museum of Natural History is the principal center for physical oceanographic research (including doctoral thesis research) in France. It is like a beehive of intensive enthusiastic activity. As an example, when I asked one of the researchers a question about some research findings of my own, he took me into the seminar room where about a dozen graduate students were holding an after-lecture rap session with their professor. The researcher handed me a piece of chalk and asked me to explain my question to the students. I gave a short impromptu outline of the problem which was followed by a very lively discussion by the students. (Wayne V. Burt)

ENERGY

FUTURE ENERGY CONCEPTS

No one doubts that we will run out of petroleum and natural gas within decades, and out of coal within centuries—what argument there is concerns the distinction between, say, three and six (decades or centuries, respectively). Then there is the atom, but even the most enthusiastic supporters of nuclear energy can hardly look with equanimity at a world in which we would use as much energy as now, or even more, and most of it coming from nuclear fission. There are three basic problems associated with uranium-fueled reactors, and these (three) problems are probably even more serious in the so-called breeder reactors which might use thorium as well as uranium: There will be immense amounts of long-lived radioactive waste products; there will be immense production of material that could be diverted for use in bombs; and there will be the possibility of catastrophic mishaps leading to explosions and contamination of large areas. Since none of the options looks promising, where do we go from here?

This question was the subject of a three-day conference, 30 January to 1 February, 1979, on "Future Energy Concepts," held at the London headquarters of the Institution of Electrical Engineers, in the shadow of Waterloo Bridge on the north bank of the Thames. The subject must be of great interest to a lot of people, because in spite of the plethora of energy conferences, and in spite of a fee of nearly £100 (which did not include any meals), there were more than 400 attendees. The majority of these were British, but there were many others, some from quite far away, including delegations of 7 from Egypt and 2 from Indonesia.

The alternatives (other than fossil fuels and nuclear fission) are of

two types: nuclear fusion and energy from the sun. Fusion, if and when it comes, will have much less severe problems than fission; but there are significant scientific questions to be solved before we will know whether any of the current lines of R&D (such as Tokomaks, or laser-induced implosion of pellets) will ever be practical. Energy from the sun may be direct or indirect; the latter includes things like wind- and tide-powered devices. In each of these, the science is for the most part completed, and only engineering questions or technology development remain. Nonetheless, these engineering questions are far from trivial. It is of little use talking about all the environmental advantages of solar energy if a kilowatt hour of energy produced in this way will cost five or ten times as much as the same energy produced from fossil fuels. The developed countries are not prepared to reduce their energy consumption substantially, and it is economically impossible for them to continue to consume so much energy at five or ten times the cost. Even worse than cost is the energy inefficiency of some systems; there is little advantage to a device that requires n joules to build, and can generate less than n joules during its lifetime (which appears to be true of some domestic solar energy devices constructed of energy-intensive materials such as aluminum).

The greatest strength of this conference was the enthusiasm of some of the advocates for particular schemes. But this was also its greatest weakness, since it was hard to distinguish between reliable assertions and those tinged by enthusiasm. Thus one of the protagonists for a hydrogen economy (in which all of our fossil fuels are replaced by hydrogen) showed a slide of some of the advantages of hydrogen, including the fact that the ignition temperature was 257°C for gasoline and 574°C for hydrogen. My own guess is that the ignition temperature of hydrogen is not far above room temperature, depending on concentrations of hydrogen, oxygen, and inert gases, on pressure, and on the presence of catalysts. I have worked with both hydrogen and gasoline, and I find the former much more frightening than the latter; this speaker, who has published books and papers on the subject, has not actually worked with hydrogen. Thus, a bit of caution seems very much in order when assessing some of these concepts and proposals.

Some of the ideas under discussion at energy conferences are literally out of this world—specifically the satellite solar power systems involving generation of solar energy at an altitude of 23,000 miles, which was the subject of one of the conference papers.

The organization of the conference was via "rapporteurs," a system I had not seen in the US but which I understand is not uncommon here. All of the papers were printed and available to attendees in advance. There were no simultaneous sessions. At a typical plenary session, a keynote address on the general topic of the session was given, and then a "presentation" of all of the technical papers in the session was made by the rapporteur, followed by discussion. Obviously not very much of each paper could be presented. Some rapporteurs tried to present an abstract or overview of each paper, but since there were an average of about a dozen papers in each session, this couldn't be very thorough. Other rapporteurs tried to outline some of the controversial points in the technical papers that might then become suitable subjects for discussion, but this frequently degenerated into "the author's Figure 4 shows a C.O.P. of 2.6, which seems incompatible with equation 13." How well the system worked depended, of course, on the individual rapporteur—his personality, and how well he had done his homework. But even if he tried very hard, he had to assume that his listeners had read the papers; and, of course, the overwhelming majority had not. Further, each session lasted an average of 90 minutes; but 60 of the 90 minutes were scheduled for the keynote address and the rapporteur's remarks, leaving totally inadequate time for discussion. There was never a chance for give and take, and the session chairmen were continually urging people to be brief, which is dispiriting.

In most technical meetings there are simultaneous sessions, and this leads to the possibility of meeting friends and/or doing a little politicking in the corridors on the excuse that one is going from one session to another. Here, one had to be in THE Session at all times, and I found it exhausting going from technical session to technical session to coffee to technical

session, from 0930 to 1900. Furthermore, I did not meet as many people as I would expect to meet at such a conference, simply because there was no place to meet and talk. All in all, therefore, I am forced to state, regretfully, that the organization of this conference was far from optimum.

In addition to the 90 technical papers, there were 16 addresses, including the 8 keynote addresses mentioned above. These addresses generally tried to cover rather broad fields. The technical papers themselves were sometimes broad ("The absorption of energy from ocean waves," "High-temperature batteries," "The economic assessment of future energy schemes") and sometimes very narrow ("Materials for windmill blades," "Fluid-bed combustion coal-fired steam locomotive," "Sputtered thin film solar cells").

An unusual and interesting feature of the conference was one of the 16 addresses, given by a man who styled himself "a token oddball." He was W.C. Patterson, of Friends of the Earth, Ltd., a pro-environment, anti-nuclear group. He was a most effective speaker and drew applause from the audience at the conclusion of his presentation. He cited the usual figures about our energy profligacy, and deprecated it. But on this point I do not believe he would have gotten much argument from the more conventional speakers; several of them had also stressed the need for reform in our wastefulness toward energy. But from both Patterson and the conventional speakers we heard mostly the "we've all-got-to-bite-the-bullet" kind of thing. Unfortunately, no one talked about how to force Americans to drive smaller cars or pay higher gasoline taxes; or how to force Britons, who love fresh air, to close their windows in the wintertime. Patterson is not technically trained. He said that as a professional writer he worried about using words properly; and he gave as an example the fact that people who used to talk about "fuel" have suddenly started talking about "energy." However, I believe that he confused energy conversion with energy degradation, presumably because he did not understand the concept of entropy. That is, "energy conversion" usually refers to changing from one useful form of energy to another, as from chemical to mechanical when we use gasoline to propel a car; the "conversion" of electrical or chemical energy into heat is trivially easy when that is what is wanted, but normally we are doing our best to avoid this degradation. However, Mr. Patterson's presentation was very well received.

Another fascinating presentation was given by Sir Hermann Bondi, Chief Scientist of the Department of Energy, and one of the famous names in the British establishment. (He has been Chief Scientist of the Ministry of Defence and has held other influential positions). He was pinch-hitting for Tony Benn, Secretary of State for Energy. (In the UK, "Secretary of State" merely means cabinet officer and has no relationship to foreign affairs.) Benn is a controversial figure, one of the most left-wing members of the Labour government, so his address would presumably have been quite different. I enjoyed Bondi's anecdote about a man who had inherited money and was in a quandary as to whether to invest in high-yield risky securities or low-yield safe ones. Seeking advice from his mentor, he was told: "It depends on whether you want to eat well or sleep well." That seems to summarize our energy options. If we want to sleep well, knowing that we have ensured against a catastrophe a generation hence, we must spend a lot of money now, which means that in the immediate future we would not eat so well. It does not appear that we are spending enough now.

The eight technical sessions were on geothermal energy and heat pumps; waves and tides; storage; wind power; advanced combustion; systems and economics; solar energy (science); and solar energy (applications). The fact that there were two sessions on solar energy and only half a session on geothermal energy presumably reflected the number of papers that had been submitted rather than any overall judgment of the importance or value of these fields, or their relevance to the nominal subject of the conference. A couple of topics were not mentioned at all: the temperature difference between the ocean surface and the deep waters was one; the other was the osmotic pressure differential between the fresh waters of rivers and the salt waters of the ocean. A back-of-the-envelope calculation shows that there is enough osmotic energy in the major rivers of the world to solve all our problems, if we could figure out how to put it to work.

But thus far, no one seems to have come up with a technology which is close to being economically feasible.

Since there were 90 technical papers at the conference, and I did not actually hear any of them in full, I will not attempt to review any of them. They are in the Proceedings, which may be obtained from IEE, P.O. Box 26, Hitchin, Herts. SG5 1SA, UK.

A few words will be added on some of the keynote addresses:

Dr. N.L. Franklin (Chairman and Managing Director of the Nuclear Power Co. Ltd, UK) contended that new thermal reactors cannot be justified on economic grounds. He predicted that light-water reactors will continue to improve; and while "eschewing optimism except in the triumph of reason over prejudice," he believed that the present European fast-breeder systems will demonstrate technical and engineering acceptability during the 1980s, although the economics may remain questionable.

Dr. J. Gibson (Member for Science, National Coal Board, UK) pointed out that coal may have to be substituted for other forms of energy sources, and that the National Coal Board is preparing for such substitution. He also pointed out that it is widely believed, but nonetheless quite wrong, that the best of Britain's coal has been used up. Dr. A.W. Pearce (Chairman of Esso Petroleum Co. Ltd., UK) spoke for the oil industry. He was benevolent in his assessment of the past performance of that industry and optimistic about the availability of petroleum supplies in the future.

Sir Kingsley Dunham, FRS (Professor at the Univ. of Durham), spoke on geothermal energy. He pointed out that a thermal gradient of 10° to 30°C per km exists in almost all of the earth's crust, so that one does not have to go down more than a very few kilometers to find ample heat. The total effluxion of earth energy is a bit less than one thousandth of the influxion from the sun, but it is nonetheless extremely large and therefore worth harnessing. However, it is too difficult to go very deep. Magma, which is extremely hot, would be a desirable source, but it only comes near the surface in regions that are volcanic and therefore inherently dangerous. Water heated by magma comes to or near the surface in a few ("thermal") regions such as California, New Zealand, and Iceland, and is being used; but it has a number of serious problems, such as being extremely corrosive, as well as polluting both the air and the water. Finally, one can pump cold water into hot rock and pump up hot water. Fracturing of the rock is necessary if this is to work, but such fracturing may be spontaneous when cold water is introduced to hot rock. Experiments now taking place in New Mexico are promising, and this could be an important future source of energy.

The keynote address for the session on Storage was given by a Dr. M. Barak, identified only as "consultant." Storage is an important part of many schemes, especially wind, solar, and others which are intermittent and unpredictable. Current large-scale energy storage for the most part involves pumping water uphill when there is excess power and letting it run back down later when energy is needed. This is unlikely to be economical except in those systems that already have water and a dam available, i.e., hydroelectric systems. Storage schemes should return about 75% of the energy stored, and their value will increase as low-fuel-cost base plants (e.g., solar) come on line. Some of the technical papers in this session were on fascinating concepts: compressed air, metallic hydrides, calcium hydroxide (i.e., the heat of slaking lime), and liquids such as oil that can be thermally cycled; but Barak spoke only on three systems: batteries, fuel cells, and hydrogen. On the last-named he showed a slide (not his own) which graphed the price per BTU of hydrogen, which kept going down, and gasoline, which kept going up, until they crossed in 1981, after which hydrogen became increasingly more economical than gasoline. (He did not say whether he believed this result, but I do not.)

There was a session on "Advanced Combustion" with 14 technical papers, mostly on fluidized beds, a modern, more efficient way of burning coal, which appeared to have attracted a great deal of interest from the audience. There was also a session on Wind Power and one on Waves and Tides. These two are to be covered in a separate report by LCDR Clayton H. Spikes.

It is my personal opinion that there really is not enough new material to begin to justify the innumerable energy conferences that are being convened these days. But since the

demand seems to be there, they will presumably continue to proliferate. (Robert E. Machol)

Editor's Note: The subject of Energy has also been treated in a number of other articles in this publication. The reader may wish to refer to these, as follows: Nuclear Energy - *ESN* 31-3: 106; 31-4:150; 32-5:163. Energy from Wind, Waves, and the Sea - *ESN* 31-8:302; 32-4:122; 124; 128; 33-3:86; Solar Energy - *ESN* 31:8:307; 31-10:396; 33-3:85. Space Heating - *ESN*31-8:305; 33-3:83; General - *ESN* 32-1:4.

GETTING CHARGED UP IN THE UK: THE ARMY-NAVY-AIR FORCE GAME IN BATTERY RESEARCH: PART I - ARMY

The UK's Ministry of Defence (MOD) operates a network of R&D laboratories, each of which tends to specialize for one of the three military services, Army, Navy or Air Force. Examples of such laboratories are the Royal Armament R&D Establishment (RARDE) in Sevenoaks, Kent, where about 90% of the work is related to Army applications; the Admiralty Marine Technology Establishment (AMTE), located at a number of sites, one being at Holton Heath, Dorset, which concentrates on Naval R&D; and the Royal Aircraft Establishment (RAE) in Farnborough, Hampshire, which is primarily an Air Force lab. This note is the first in a series of three, the purpose of which is to examine the MOD scene in battery R&D, using as a basis the activities at these three establishments, which were all visited recently. After a general introduction, this first note will review battery research at RARDE; next month's installment will consider AMTE; and the final section will discuss RAE.

It is important to note that these three certainly do not comprise the entire MOD battery effort, as there are many other MOD laboratories and non-MOD institutions involved in the picture. Also, RARDE, AMTE, and RAE all maintain extensive extramural research networks in order to develop the comprehensive battery R&D programs that are necessary to their particular interests. Thus the overall program at each of the labs includes a set of programs at industrial concerns (mostly battery manufacturers) and academic institutions; these extramural programs complement the relatively limited amount of intramural work that the laboratories' staffs and facilities can sustain.

The natural division of effort between the Army, Navy, and the Air Force laboratories is in terms of applications. In each case the range is quite wide, sometimes overlapping, and there is a diverse array of battery types involved. The Army applications emphasized at RARDE tend to be related to ordnance, tracked and wheeled vehicles, land mines, etc. Battery types of particular interest include lead-tetrafluoboric acid reserve cells ($Pb/HBF_4/PbO_2$), silver-zinc layer cells ($Zn/Mg(ClO_4)_2/Ag\ Cl$), nickel-cadmium alkaline cells (Cd/KOH/NiOOH), and various zinc alkaline cells such as ($Zn/KOH/MnO_2$). The Navy interests as embodied at AMTE are mainly in reserve batteries such as for torpedo propulsion, water mines, sonobuoys, emergency lighting, and (to a lesser extent) submarine propulsion. Battery types of interest include pyrotechnically-activated thermal (molten salt) batteries and seawater-activated batteries. For the Air Force, the usual range of contemporary aircraft and guided weapons applications are of interest although the RAE program particularly tends to spill over the tri-service boundaries and encompass a very wide range of battery types. The requirements and activities in some of these various areas will be described as this series of notes proceeds.

RARDE-Army: Battery research at RARDE is in the Electrochemical Power Sources Group, which is currently in the EM-2 branch under Dr. F.W.S. Carver; it was until recently in the EM-4 (Materials) branch under Dr. Roger Warren, who during a recent visit introduced me to Dr. T.J. Sinclair and Mr. T. Keily, two of the Group's key researchers. As with all three MOD labs under discussion, the RARDE battery group has several roles. They act in a consultative capacity, provide advice on battery selection, and evaluate commercial batteries for future Army applications. This is in addition to conducting in-house basic and applied research and managing the extramural research program. The overall aim of the program is to improve the characteristics of the electrochemical couples that are of interest. The relevant applications

most frequently call for a low-voltage primary battery with long (5-10 years) storage capability, small volume, and adequate capacity (typically about 1 Whr). Batteries of interest include alkaline Ni/Cd, layer cells of AgCl/Zn with magnesium perchlorate electrolyte, reserve batteries such as Pb/PbO_2 with fluoboric acid electrolyte, lithium, and many others. Both primary and secondary batteries are of interest.

As an example of the cooperative work with industrial concerns, over the last few years RARDE has worked with the McMurdo Instrument Company to develop a $Pb/HBF_4/PbO_2$ reserve cell capable of operating for at least 24 hours after activation in the temperature range -30° to +60°C. Prototype cells are being evaluated at RARDE, and a related intramural study of HBF_4 solutions has established the effect of electrolyte impurities (particularly Cl^- and SO_4^-) on the Pb/PbO_2 couple. Also for the $Pb/HBF_4/PbO_2$ reserve system, battery plate material manufactured on a stainless steel substrate has been tested in annular stacks, and work is underway to translate the lead-plating process on stainless steel from the laboratory to the industrial plant. Research is also underway on the effect of intrinsic stress in electrodeposited PbO_2 on its electrical performance, and an investigation has started on the feasibility of simultaneously depositing lead and lead dioxide from the same solution.

I have never envied the task of the military, who are expected to be ever-ready to do anything, while at the same time we hope they are not called on to act in full. Thus the Services in peacetime tend to spend a lot of effort in maintaining readiness, rather than making heavy use of systems. This has a special influence on their power source systems and on research in this area, and this is particularly noticeable in the RARDE battery research program. Battery storage life is one of the group's great interests, and cold storage in particular gets a lot of attention.

Cold storage is a time-honored method of extending battery shelf life and, in fact, sometimes leads to a form of "dead-battery-paranoia" among battery men, who may avoid buying dry cells in overly warm shops. However, cold storage does have its drawbacks, one of which is possible passivation problems. Battery people therefore are often faced with thermodynamics/kinetics dilemma: they want batteries that will perform when called on in cold weather, yet the deterioration rate must not be too high while being stored on standby. Various types of storage tests as well as fundamental studies of passivation phenomena are underway at RARDE concerning a range of reserve battery types.

For example, the use of sealed Ni/Cd alkaline cells for single-duty-cycle application involves certain novel features for which little or no quantitative knowledge exists. This particular application requires a rapid recharge secondary cell that will experience only one duty cycle. In essence, the requirement is for a primary reserve system activated by electrical input. This involves a number of unusual features for secondary cells. For example, the cells may be stored for periods of up to 10 years at temperatures ranging from -40 to +70°C. If to be put into use, the cells are then rapidly charged (< 1 hour), the goal being to obtain an energy density of 40-50 Whr/lb.

In the case of the storage life problem for alkaline primary batteries, one of the limiting mechanisms is self corrosion of the anode material. While cells based on Cd appear quite resistant to deterioration, the higher voltage cells based on zinc require alloying, typically with mercury up to 10%, to increase the hydrogen overvoltage, and these alloys tend to have lower corrosion resistance. Recently, in cooperative work with the Metallurgy Department at the City of London Polytechnic, Zn-0.05 to 1.0 wt% Cd alloys have shown promise of being compatible with battery discharge requirements as well as having satisfactory self-corrosion characteristics. Corrosion rates were measured by monitoring the volume of hydrogen evolved and the discharge behavior characterized by means of galvanostatic chronopotentiometry and potentiostatic anodic polarization studies. The influence of zinc oxide saturation of the KOH electrolyte on corrosion rates was studied. Alloys in the range Zn-0.05-2 wt% Cd exhibit better corrosion resistance than pure zinc. Saturation with ZnO inhibits corrosion, as does amalgamation, while the tendency to passivate increases with Cd concentration.

As usual at the MOD labs, these basic studies are only half the story,

and at RARDE actual long-term battery storage tests are also being conducted. Patience is definitely a virtue in this work. Hundreds of batteries are constantly under various types of surveillance, or are simply being stored until the opportune time for examination. For example, recently a 10-year study was completed on nearly 600 $Zn/Mg(ClO_4)_2/AgCl$ 3-V batteries. The simple conclusion after painstaking electrochemical and physical analysis of the cells was that the batteries are capable of post-storage operational reliability over a wide temperature range, i.e., do meet the service requirements. This is obviously a long way from "eureka" research. Also in connection with battery storage, a special development of the group is a capacitor-charging device to evaluate the capacity of primary batteries, calibrating the rate of charging to the capacity. The aim of this is to simplify and standardize a method of evaluating post-storage condition. Various commerically available alkaline cells are being assessed for ordnance applications, including In-Bi/KOH/HgO, Cd/KOH/HgO, $Zn/KOH/MnO_2$, and Zn/KOH/HgO.

There is other fundamental research at RARDE related to passivation/corrosion phenomena at battery electrodes that takes on a very high level of sophistication. For example, Sinclair and his coworkers have developed a special expertise in the use of *in-situ* laser Raman spectroscopy to provide information on molecular adsorption at electrode surfaces. One of the applications of this technique is to examine the effectiveness of corrosion inhibitors in battery electrolytes. For example, it has been used recently to examine the adsorption of pyridine at a silver electrode. Also, Sinclair and coworkers are studying the behavior of porous zinc alkaline electrodes. A standard, low-porosity disc is produced by compacting zinc powder of a chosen particle size range for corrosion experiments. They have investigated the inhibition of reactions at the zinc electrode by species in 8.5 molar KOH solution using gas evolution and polarization resistance techniques and are now attempting to probe adsorbates at the electrode/electrolyte interface with the *in-situ* Raman technique.

There also is some interest at RARDE in lithium-based primary and reserve battery systems for ordnance applications, and a series of hazard trials and mechanical tests have been carried out on commercially available cells. The growing number of high energy batteries based on the lithium anode has prompted RARDE to carry out comparative abuse trials; this is done on individual cells by subjecting them to dynamic testing in accordance with a UK Standard. Various lithium cells have been studied, including $Li/org/SO_2$, $Li/org/(CF)_n$, and $Li/org/V_2O_5$.

In summary, it is probably obvious that the most prominent aspect of the battery program at RARDE is the study of long-term storage and the associated phenomena of electrode deterioration. There is considerable vested experience and sophistication in the methods applied to those problems. As is the case at the other establishments that will be discussed in this series of notes, the rather limited staff maintains activities in an impressively wide range of battery systems, and the success of the battery program as a whole is enhanced by the inclusion of a selection of complementary extramural programs at universities and battery firms. (Jeff Perkins)

ENGINEERING

PLASTIC CARS

It is conventional wisdom that in automobiles the replacement of metal with plastics will reduce their weight and decrease their fuel consumption. Actually, the issue is far more complex than this simple argument would suggest, and this topic was the subject of a formal debate at the Reinforced Plastics Congress of the British Plastics Federation (BPF) in Brighton this past November.

Before reviewing the points made in the debate, we should consider how plastics are or might be used in automobiles. Obviously, they have been used for decorative, nonstructural purposes for many years, and this represents a weight saving. Present considerations are to use plastics in more stress-critical components such as the hood, trunk lid, and the structural frame. One US auto manufacturer has designed and built a prototype rear-end spring composed of carbon fiber reinforced plastic (CFRP).

Plastics reinforced with continuous fiber, such as CFRP or glass fiber reinforced plastic (GFRP), are not the principal candidates for auto construction. Instead, this market has been staked out by thermoplastic and thermosetting resins reinforced with fillers such as calcium carbonate and chopped glass fiber. These materials are often referred to as glass reinforced plastics (GRP). As sheet-molding compound (SMC) they can be compression molded or as dough-molding compound (DMC) they can be cast or injection molded. The GRPs are much less expensive than the continuous fiber materials and can be fabricated into structures with satisfactory strength and stiffness for use in automobiles. The SMC materials having fibers 25-50 mm long compared to the 6 mm fibers in DMC are much stiffer.

The motion put forward for debate at the BPF meeting was, "Are reinforced plastics a viable material in the automobile industry?" The chairman was Mr. J. Mountifield (retired, Fibreglass Ltd, St. Helens, Merseyside) who, in his opening remarks, raised some interesting points. He noted that the US auto industry is predicting that all automobile bodies will be made of reinforced plastic by the end of this century. The European car industry does not agree. They feel economic factors will prevail. One example is the adverse effect the replacement of pressed steel would have on employment in the steel industry. Presumably union and government pressure would slow the introduction of GRP components.

Following the introductory remarks, the first speaker for the motion was a Mr. A. Hill, (Pressed Steel Fisher Ltd, British Leyland Div, Oxford). To this observer this seemed a curious choice, in view of Mr. Hill's employer. His remarks were something of a review of the advantages and problems in the use of structural plastics in autos. He pointed out that there has been a continuous attempt to replace metal by plastics throughout the history of the automobile. A double criterion has always existed: that the substituted component meet the mechanical requirements and that it be attractive. Technical innovation does not sell cars. Hill said that we must come face-to-face with energy conservation and that auto fuel consumption must be reduced. In accomplishing this by the substitution of plastics for metals, however, the auto manufacturers would like their involvement to be minimized, to reduce their liability to litigation—justifiable or otherwise. They would rather see the plastic processors be the target of irate consumers if plastic components fail.

In Hill's opinion, compression molded SMC will not be widely used except for wide area paneling such as hoods and door panels. More intricate and complex parts such as grills and dashboards are more easily made by casting or injection molding with DMC, especially if there are re-entrant angles in the design. He also sees growth in the pressure gelation forming of epoxy-based GRPs, because of their superior heat resistance over most SMC and DMC materials. Higher temperature resistance would lead to more under-the-hood applications. Hill conceded that the extensive use of GRP faces some unsolved problems; notably, painting difficulties and low impact strength. In regard to impact resistance, GRP must compete with other plastic materials such as unreinforced rubber-modified polymers, CFRP, and GFRP. In summary, he believes that the use of plastics in cars will increase gradually on a case-by-case basis.

The motion was seconded by R.W. Allan (Owens-Corning Fiberglass, Brussels) who began by citing the energy/pound for manufacturing a hood of steel, aluminum, and GRP as 28,000, 108,000 and 40,000 BTU, respectively. The last figure includes the gasoline lost by using the petroleum to produce plastic. Allan then took his calculations further to include the effect of the weight differential on the energy consumption in operating the autos. In total, the cars with steel and aluminum hoods would be 5 and 3 times more costly to produce and operate than the car with a GRP hood. (This result seems a bit extreme to this observer.)

Allan stated that the cost of GRP is not increasing as rapidly as other materials, notably metals. Also, the initial tooling investment is lower for GRP than for metals. However, the argument about tooling ignores the fact that the automobile industry is already tooled for metal working and the introduction of GRP would mean new tool investment either by the industry or the plastic processors.

Mr. Woodward (Alcan Ltd., London), speaking against the motion, began on

a facetious note with the remark, "Forty million pressed steel components a year can't be wrong." In one sense this statement is not facetious in that it reflects the maturity of metals technology. Engineers understand how to design and produce metal components, whereas a similar familiarity with plastics does not exist.

Woodward admitted that a recent aluminum industry report concluded that aluminum and steel do face a stiff challenge from plastics. However, he feels that the cost picture can change, especially if putting a high-quality finish on plastic parts proves to be expensive. He claimed that the production rate of plastic parts tends to be slower than for metals. (We should add that this depends on which part is taken for comparison.) He then cited the poor impact resistance of plastic parts, the low modulus of GRP, especially of the short-fiber DMC, and the lack of fatigue resistance data, all valid points. Woodward closed by pointing out the recyclability of metals, which is not the case for plastics, and that the claim made earlier by Allan that waste plastic can be used for fuel raises the possibility that plastic auto components represent a fire hazard.

The Chairman spoke against the motion in the absence of the scheduled seconder. His main points were that the plastics industry is unaware and unresponsive to the production problems, economics, and regulations of the auto industry, and that repair techniques for GRP are not well established.

The debate was thrown open to audience comments. H. Hill (Atomic Energy Research Establishment, Harwell) emphasized the low modulus of short-fiber GRP, even of SMC, and that to get the necessary stiffness requires continuous fiber GFRP and CFRP. However, the continuous fiber composites are more expensive and present special design problems. Allan countered that in industry the trend to stiffen GRP is to go to glass/graphite fiber hybrids or high filler loadings.

A. Bennett (British Leyland Ltd, London) stated that an energy calculation can give any answer you happen to want. He said that in terms of natural resource availability aluminum exceeds steel, but both greatly exceed the availability of petroleum. Dr. T.J. Walker (Imperial Chemical Industries Ltd, London) quickly responded that plastics need not come from oil but can be obtained from plant stuffs.

Bennett continued that in 1973 the cost of steel and aluminum sheet were between $0.50 and $1.00/per square meter compared to $2.00 for structural plastics. We should point out, however, that this price differential is probably inaccurate today and would change dramatically in favor of plastics if the volume of production of plastic components should increase abruptly.

The meeting turned into a disorganized discussion, much of which was a rehash of points already made. A few interesting comments were offered. It was noted that the total petroleum usage in one year by the British plastics industry in plastics production would keep US autos on the road for only 12 days. Another participant remarked that the political stability of oil sources could seriously affect the situation. Finally, the question was asked, "How low can the body weight of a car be reduced before it becomes unsafe to drive?"

Much of the discussion during the late hours of the afternoon reflected an important problem facing the introduction of structural plastics into automobiles. The representatives of the auto industry were concerned that engineering design data are simply nonexistent for GRP materials and that without design data the auto industry cannot confidently incorporate plastics into auto structures. On the other hand, the plastics industry, especially the processors who would be fabricating components, were unable to provide data. More to the point, there are few design engineers trained in plastics design. The Polymer Engineering Directorate is currently trying to get the UK university system to develop programs in polymer engineering. In the meantime, the UK plastics industry sees a big market that it may be incapable of exploiting.

It would seem that plastics will, in an evolutionary fashion, find their way into the critical applications in automobiles requiring strength and stiffness on a case-by-case basis, as suggested by Hill. The pace at which this occurs will depend on a number of factors, such as the development of a data base for engineering design and of engineers able to use the data. We may think we are in the "Plastics Age," but we are just beginning to see the use

of polymers in all forms of construction, simply because plastics are not energy intensive and need not be derived from petroleum. (Willard D. Bascom)

POLYMER RESEARCH AND THE PLASTICS INDUSTRY IN THE UK

In recent years plastics have been finding their way into applications in which a knowledge of their properties, especially engineering properties, is critical. For example, glass reinforced plastic (GRP) composites of glass fiber in a polymer matrix are being used in piping, storage tanks, and in aerospace, railcar and automobile construction. These applications require a sound understanding of molecular structure-property relationships and good design engineering.

To create more interaction between academic research, which has tended to be of a scientific nature, and the plastics industry, which by its nature is very applied, the Polymer Engineering Directorate (PED) was founded in mid-1976. Its formation was preceded by a series of events in which attempts were made to use the existing research funding structure to bring academia and industry together. In this article we examine the formation and function of the PED as an important experiment in government/university/industry interfacing. Also, the topic is not without relevance to the relationship between universities and industry in the United States.

Dr. Anthony Challis, Director of the PED, was kind enough to give an interview in which he described how the PED was formed, how it functions, and how it is accomplishing its mission.

The PED is part of the Science Research Council (SRC), one of the funding agencies for scientific research in UK universities. The SRC has a series of boards: Astronomy, Space and Radio, Nuclear Physics, Science, and most recently the Engineering Board (EB). The EB has been concerned with the initiation and conduct of special programs aimed at substantially increasing university-industry interaction. The PED is one of these special initiatives along with the Teaching Company Scheme, concerned with engineering education, and the Marine Technology Directorate (*ESN* 30-10:464). The approach has differed in the various cases, and the introduction of essentially application, industrially oriented efforts into the university environment by an organization traditionally recognized for its interest in fundamental science has not been without its difficulties.

The SRC recognized in 1969 the need to support research in polymer science and engineering. By late 1973 it was clear that efforts in these directions had been successful in polymer science but not engineering. The Council accepted the recommendation of a working party to develop a polymer directorate to initiate and oversee a closely coordinated program of research and postgraduate training in selected universities and with active involvement of industry. By 1976 the PED was formed with Challis as director. The PED reports to a management committee composed of representatives from groups contributing to the funding of the Directorate (British Plastics Federation, British Rubber Manufacturers Association, and the National Research Development Corporation), industrialists, academics, and representatives of the Department of Industry and the Rubber and Plastics Research Association.

To accomplish its mission the PED needs to create polymer engineers; engineers who have a basic understanding of the properties of polymers and how to design and construct plastic structures. To do this there must be sound test methods, a broad data base, and people educated specifically as polymer engineers. The PED is acting on all three of these fronts. It is funding, mostly in universities, basic research on the mechanical and rheological properties of polymeric materials. Much of this work is still in the test-method development stage but will eventually begin to generate data. Processing polymers into structural components, e.g., injection molding, filament winding of composites, and adhesive bonding is to a large extent an empirical art. The PED is funding cooperative university-industry research in this area.

As for creating polymer engineers, the PED is following two approaches. First, to entice existing engineering departments to develop expertise in polymers, Professor S. Gill at the University of Manchester Institute of Science and Technology (UMIST), an expert on the design of pressure vessel end-

caps, is being funded to develop design methods for GRP end-caps. Courses in polymer engineering are now being given at UMIST. Second, the Loughborough University of Technology has developed for the PED an educational program specifically designed to produce polymer engineers. As currently constructed, engineers in industry are invited to enroll for an MSc in polymer engineering. Challis describes this as a "hands-on" program that leaves the student knowing as much about polyethylene as he does about mild steel.

The PED strives to get much industrial participation in its research programs. Many of its academic contracts have a plastics company actively involved in the research, assisting in the funding or acting as advisor. Also, the company gets involved at the beginning of the work so that it goes (industrially) in a meaningful direction right from the start.

A special example of industry-university cooperation is a consortium of resin manufacturers, fiber producers, and GRP fabricators organized to fund university R&D for better design specifications for the use of GRP in the chemical industry. Half of the funding comes from industry and half from the Government, mostly from the PED, but Government laboratories such as the National Engineering Laboratory (East Kilbride, Scotland) are also involved.

The PED currently has 40 ongoing research programs at a total cost of $4 million. There are 36 industrial participants conducting research and/or providing funds (1.4 million).

Unlike the parent SRC, which relies on submitted reports to review programs, the PED conducts on-site reviews and frequently invites university and industry personnel working in the same area to attend.

Is the PED a success? According to Challis, the scientific results generated by academic research are beginning to be used. However, efforts to educate polymer engineers have been disappointing. Only 4 UK students are enrolled in the Loughborough program in the first year and 8 in the second year. (Other enrollees come from outside the UK.) However, the first 4 UK graduates were snapped up immediately by the British plastic industry. Challis feels that the polymer community has yet to be persuaded that there is a need for polymer engineers. Nonetheless, the PED does have approval, if not overwhelming success. Its initial charter was for 5 years, but very recently, after 2½ years of operation, the SRC lengthened the charter to 10 years.

This marriage between university and industry that the PED has forged is based on mutual self-interest: money. Should the PED withdraw now or in the next 2 or 3 years, it is Challis' opinion, shared by some others in academia and industry, that most scientists and academic engineers now involved would retreat from what they see as applied research, and the industrial people would resume their distrust of academic "white towers." While, more than likely, communication between polymer scientists in universities and their counterparts in the large, resin producing chemical companies would continue, it is with the small resin vendors and, more especially, with the processors that, unfortunately, interaction with the universities would break down. These industries operate at a narrow profit margin and cannot support research. They have an empirical "feel" on how to design with polymers, which is simply not good enough for the use of polymers in strength-critical structures. Clearly, one good polymer engineer in each company could make a big difference. Perhaps after ten years of interaction the situation will be different.

The polymer science community as a whole will certainly benefit from the research output resulting from PED funding. On the industrial scene, the situation in the Western world as a whole seems much the same as in the UK, especially with respect to the marginal capability of the plastics processors in engineering design. Many countries, including the UK, are looking to the United States for developments and innovation in the use of structural plastics, notably for automobile and aircraft construction. If the PED is successful in upgrading the engineering capability of UK plastics industry, they could upstage their US counterparts. (Willard D. Bascom)

ANTENNAS AND PROPAGATION ON SAVOY PLACE

Approximately 650 persons attended the first international comprehensive conference in Western Europe devoted to "Antennas and Propagation," held recently in the IEE building, on Savoy Place, London, under the watchful eyes of portraits of Michael Faraday, Lord Rayleigh, and other luminaries of the past. Chairman of the organizing committee was Prof. Peter Clarricoats (Queen Mary College, Univ. of London), who is also this year's Chairman of the Electronics Division of IEE. The conference participants hailed from virtually every country in Western Europe (except such small states as San Marino, Andorra, etc.) There was also a sprinkling of attendees from Eastern Europe and a minor representation from the US and such countries as India and Australia.

Topics discussed were split into the two different fields of "antennas" and "propagation," so that the Proceedings could be issued as two volumes: An Antennas section of 452 pages and a Propagation section of 186 pages. The antenna papers dealt separately with the topics of arrays, adaptive antennas, reflectors and radomes. HF and VHF antennas, measurements, numerical techniques, contoured beams, reflectors, feeds, scattering and diffraction, conformal and planar antennas, and theory and practice. Propagation topics were remote sensing and propagation over sea surfaces, effects of ground and atmospheric irregularities, the ionosphere, propagation through rain, scattering from hydrometeors, and earth-space propagation (including a workshop dedicated to OTS, the Orbital Test Satellite).

A number of invited speakers, each addressing a plenary session, highlighted the meeting. In the lead-off paper, R.C. Hansen (R.C. Hansen, Inc., Tarzana, CA 91356) summarized recent advances in scan and adaptive (nulling) antenna arrays. According to Hansen, progress in phased arrays has dealt with mutual coupling in arrays and its manifestations: Matching of infinite arrays through multi-modes and networks and the intrinsic limitations thereof, edge effects in finite arrays for both single mode and multi-mode elements, and the synthesis of slot arrays taking coupling into account. Work on adaptive nulling or steering arrays, though less easy to pinpoint, has dealt with "slow loop convergence due to small eigenvalues," signal destruction in power inversion arrays, achieving wide-band adaptation, and obtaining improved algorithms.

In the paper entitled "The ionosphere as a propagation medium—an engineer's view," E.D.R. Shearman (Univ. of Birmingham, UK) surveyed the present state of knowledge about the ionosphere as it affects electromagnetic wave propagation in bands from VLF to VHF (3 kHz to 300 MHz), some of the outstanding problems in relevant atmospheric physics, and the predictive forecasting used to optimize communication.

As is well known, the 3-30 kHz range is particularly useful for global navigational aids, because here the variations of time delay of the sky wave are less than in other bands. Propagation at these low frequencies takes place by waveguide modes between the D-layer of the ionosphere and the ground, with two TM modes dominant. Among the problems to be solved is that there may be locations where the two modes may interfere destructively and thus make location identification difficult.

In the 30-300 kHz range (navigational aides, broadcasting and low-speed data transmission) problems have arisen recently because of reallocation of some channels, in response to increased demand for service. Shearman made reference to some theoretical work at the British Broadcasting Corporation (BBC) that has led to a partial resolution to some of these problems.

In the HF band, 3-30 MHz (fixed, maritime, aeronautical communication, international broadcasting, and sky wave radar), a number of organizations are presently re-equipping stations to take advantage of the modern techniques of frequency agility, stability, and adaptivity. Work is in progress to establish routine services that use computer ray tracing through ionospheric models for predicting propagation. (Unfortunately, these cannot account for traveling disturbances such as the ionospheric disturbance caused by the explosion of a chemical plant and found by observers at Leicester Univ., 50 miles away.)

Although in the 30-300 MHz band propagation is by line of sight, even here there are ionospheric problems, such as co-channel interference because of sporadic E ionization or signal scintillation in space-ground communication.

Shearman concluded his talk by relating the various physics investigations of the ionosphere, information obtainable through these, and the use of such features as adaptivity by selection of the proper frequencies.

In the paper entitled "New developments in VHF/UHF antennas" F.M. Landstorfer (Technical Univ. of Munich, FRG) described work in progress during the last several years in Munich, based on optimizing signal-to-noise ratio of VHF/UHF receiver systems by improvements of either antenna gain or by the reduction of receiver noise.

In the VHF/UHF range, antenna dimensions are of the order of a wavelength; so that maximization of gain by increasing antenna size is usually not practical. Landstorfer's contribution towards increasing antenna gain—a significant advance—has been to shape the antenna so as to make use of the phase delay of a signal traveling through space. Thus, while the 1.5λ straight dipole of Fig. 1(a) has rather poor radiation characteristics in directions perpendicular to the wire, Landstorfer's antenna of Fig. 1(b) has a gain of 7.8 dB. This scheme has been extended to the two-dimensional system of Fig. 2 and to the Yagi-array of Fig. 3. The technique has also been included in a log periodic array.

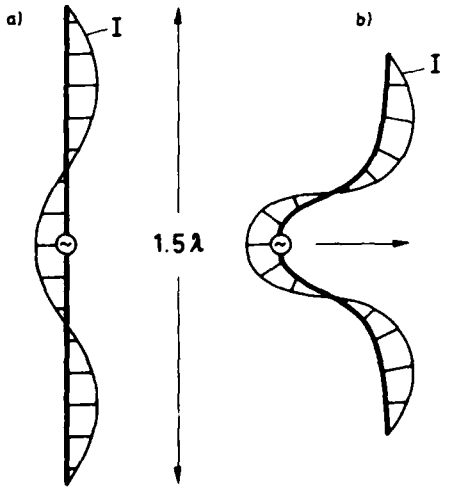


Figure 1. Method of increasing antenna gain.

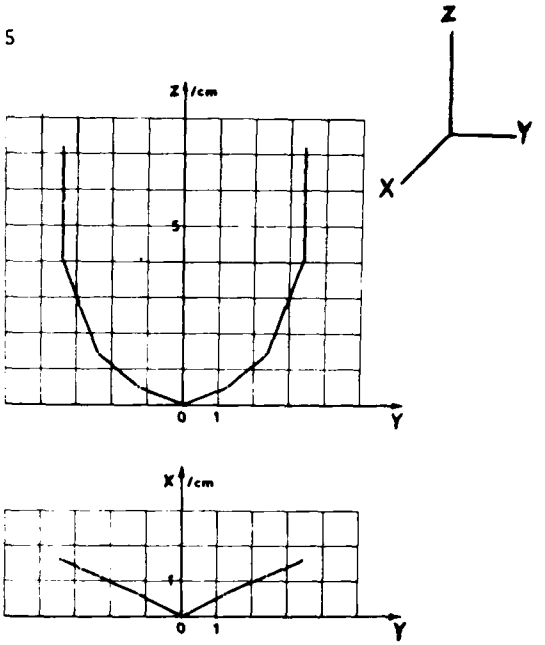


Figure 2. Dual-wire antenna of optimized shape; L = 0.75λ.

Landstorfer's method of optimizing signal-to-noise ratio has also dealt with the so-called "active antennas" that were first investigated at Ohio State Univ. He discussed an active antenna for a helicopter homing system that covered the range from 30 to 80 MHz, stating that the active dipole antenna of this system was smaller by a factor of 3 than corresponding passive dipoles, with equal or better signal-to-noise ratio. While such a result is indeed significant, it appears not to have been accepted universally. At least one antenna expert with whom I discussed the pros and cons of active antennas after Landstofer's talk was very skeptical of their utility.

In the talk entitled "Millimeter Waves—Propagation and Application," D.C. Hogg (National Oceanic and Atmospheric Administration, Boulder, CO) stated that while millimeter waves have not had much impact to date, some applications are now surfacing quite strongly. Some of these are satellite and, to a lesser extent, terrestial communications; remote sensing of the atmosphere for weather forecasting purposes; and recognition systems for the military. (Although radio astronomy has also been very active in this range, Hogg limited his discussion to the first two topics.) He stated that an

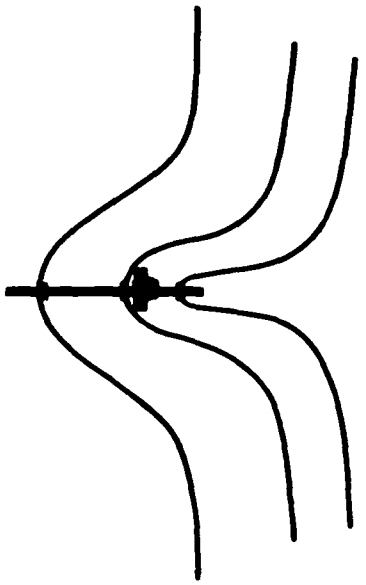


Figure 3. Modified Yagi-array.

unfortunate characteristic of millimeter wave propagation is the large attenuation in rain. This, however, does not prevent use of such waves for local communication by employing a beam-wave system called the "Hertzian Cable."

The large attenuation of millimeter waves mandates that if this range is used for communication by satellite, site diversity must be provided. A number of experiments here remain to be performed.

Perhaps the greatest use of millimeter wave propagation is in remote sensing, where the losses and other electromagnetic properties of the atmospheric constituents offer useful signatures. In other words, concentration of such quantities as water vapor and liquid in the atmosphere can be measured by looking at the attenuation of a millimeter wave signal. Hogg discussed this in some detail and also mentioned a type of antenna receiving system that had been devised for the sensing operation.

The status of antenna and propagation work in what surely must be a most exciting effort, not only because of the variety of work, but also because it involves the close coordination of groups from a number of countries, was described by J. Aasted of ESA, the European Space Agency (ESTEC, Noordwijk, The Netherlands), in the final invited paper of the Conference. The work touched on was so numerous in extent that only a few of the salient points can be mentioned here, as follows: (1) The antennas discussed in the 1975 IEE conference "Antennas for Aircraft and Spacecraft" and described in IEE Conference Publication No. 128 (available from IEE, P.O. Box 26, Hitchin, Herts SG5 1SA, UK) have been performing well on the satellites for which they were designed. (2) The telemetry and command function for satellites is to be moved from VHF to S-band. A new, slotted waveguide antenna with skirt, of cardioid radiation pattern, is currently in the stages of final development. (3) An improvement over the shaped reflector system of the MAROT payload has been designed and constructed. This system, for communication with mobiles in the 1550-1650 MHz range, is a phased array of 18 elements. Its increase in gain of 6-7 dB over that of the shaped reflector is obtained at the expense of somewhat greater onboard complexity. The latter seems to be the coming trend. (4) An important consideration for communication with fixed terminals (11- and 14-GHz bands) is the utilization of both polarizations of the radiation as separate channels, therefore requiring minimum cross-polarization interference. Here significant contributions have been the recognition that the major difficulty has been the antenna feed and its support, and the resulting development of the off-set antenna of Fig. 4. Aasted stated that such offset systems (or systems that have the same characteristics) will be especially needed for the direct TV broadcast satellites. (5) There is great interest in the use of the

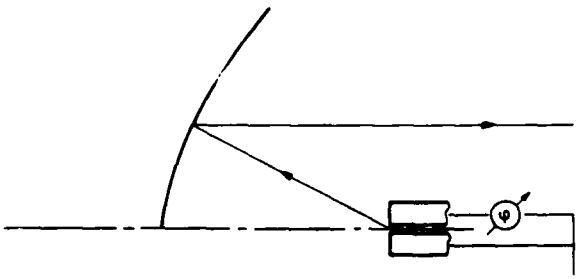


Figure 4. Off-set antenna for minimum cross polarization.

higher microwave frequencies (20-30 GHz). Their use will require RF sensing to utilize the narrow beams possible; very long test ranges with "near field" facilities; and improved thermal test methods for verifying antenna behavior in space. (6) Aasted also discussed the importance of various computer programs and their use in extensive calculations of antenna behavior, of near field test techniques, of six years of propagation measurements including a development of fade characteristics, a campaign to develop a European climatic map from 20-30 GHz radiometer measurements, and experiments aimed at 55-65 GHz satellite-to-satellite links.

Because of the great interest in satellites, the conference had a workshop dealing with the propagation studies carried out with the OTS. This Orbital Test Satellite has been discussed in a number of publications of ESA. I have been told that information on this program could possibly be obtained from Mr. P. Bartholome, Communications Satellites Department, ESTEC, Domeinweg, Noordwijk, Netherlands.

Because of space limitations, it is only possible to refer to a few of the contributed papers. In one of these, A.P. Anderson et al. (Univ. of Sheffield, UK) demonstrated a technique whereby imperfections in a large reflector antenna (panel misalignment, malformations, astigmatism owing to gravity loading, etc.) were seen in a type of contour map on a color TV display. To get such results, a ground-based source illuminated the 25-m diameter reflector from 0.9 km away (within the Fresnel zone) while this reflector performed a zig-zag scan of ±2.7° under computer control. The signal received by the reflector feed, mixed with a reference signal, provided the data from which the imperfections were calculated.

That there is current emphasis in military radar systems on phased-array antennas with the capability of agile beam steering could be noted from the paper "Numerical and experimental antenna patterns of a planar, space-fed, phased-array antenna," by H.J. van Schaik (National Defense Organization TNO, Netherlands). Target detection in three dimensions by mechanical scanning in the azimuthal plane and IF processing in the elevation plane, using the "Martello" 3D Radar Antenna, was described by R.W. Ashton et al. (The Marconi Research Laboratories, UK).

The Channel Islands, which are British but lie tucked away between the Cotentin Peninsula and Brittany, of France, receive their color TV signals from Stockland, England, via a UHF link. A problem with this system is co-channel interference (of varying amounts) from stations both within and outside of the UK. M.D. Windram (Independent Broadcasting Authority, Crawley Court, Winchester, UK) discussed an adaptive array of 16 elements for nulling out the interference. Each of the radiating elements is connected to a network that adjusts phase and amplitude of its output in a manner that effectively nulls interfering signals as they occur. Another adaptive array system was described by S. Lehto et al. (Univ. of Oulu, Finland). And along the same vein, a clever, simple, and very compact four-element circular omnidirectional array with one deep, steerable null was described by D.E.N. Davies and M.S.A.S. Rizk (Univ. College, London). The four elements are fed by both a uniform signal and one that varies in phase by 90° from element to element around the circumference. By varying the relative phase difference between the two signals, a steerable null in the radiation patterns occurs.

Microstrip antennas have become important components of some microwave systems in recent years. Since they conventionally take the form of resonating strips from which radiation occurs at the apertures of the open-circuited ends, they are bandwidth limited. C. Wood et al. (Royal Military College of Science, Shrivenham, UK) in "Design of wideband circularly polarized microstrip antennas and arrays," discussed modifications to curved line systems to improve the bandwidth by a factor of five over conventional microstrip radiators, at some sacrifice in efficiency. (Typical results: bandwidth from 8 to 12 GHz, efficency 50%, ellipticity less than 3 dB, gain 0-6 dB.) To produce a high gain system, a travelling wave array concept based on radiation from line corners was demonstrated. (Bandwidth at 17 GHz of 6%, gain 27.6 dB, efficiency 32%, ellipticity less than 3 dB.)

While among the propagation papers there was much emphasis on the influence of rain on signal polarization and on

signal fading in communication links, there were also reports of other studies. For example, J.H. Causebrook (BBC, UK) found that the field strength vs. distance relation in built-up areas was different from theoretical predictions, so that additional measurements will be required for a more complete understanding of the phenomena involved.

Finally, according to a paper by Sandham et al. (Univ. of Birmingham, UK) it is now possible to get important information about the state of the sea by the use of MF/HF radar, utilizing Bragg scattering and Doppler shifting of signals by ocean waves. By this technique directional wave-energy spectra, surface winds, and surface currents can be determined over a large area of the ocean from land based transmitters.

As is seen from the above summary of invited and some contributed papers, much interesting information was disclosed at this conference. Individuals interested in a much more complete report of papers presented may obtain copies of the two-volume Proceedings (Conference Publication 169) from IEE, P.O. Box 26, Hitchin, Herts, UK. The price of the set for overseas subscribers is £30.50. (Irving Kaufman)

A VISIT TO A POLYTECHNIC—AND A SUCCESS STORY IN SIGNAL PROCESSING

In a recent issue of this publication two of my colleagues described in general terms the history and mission of the polytechnics in Britain (*ESN* 32-6:203). In this note I shall describe the organization and functioning of one of these institutions, the Polytechnic of Central London, some research in the school of Engineering and Science, and some specifics on an activity in Signal Processing Research launched there by a young American, Dr. Gerald D. Cain.

After several months in Britain and conversations with a number of individuals from those institutions known as "universities," I have found that many of the academic community here view establishments of higher learning as existing in three layers. On top are Oxford University and Cambridge University, not necessarily because they are the oldest (1264 and 1269, respectively), but because they have made great contributions for a long time, continue to do so, and are also financially very well endowed. In the second layer we find most of the other institutions that are also called "universities." It would be difficult to categorize all of these in order of importance, however, for some are better established in one discipline than in another. (For that matter, even Oxford, in the top category, is not nearly as strong in Engineering as, say, Imperial College of the University of London.) The third layer is generally thought to comprise the other institutions of higher learning, which includes the Polytechnics. While this ranking of British institutions seems to be the opinion of many University professors or lecturers, it is probably far too simplistic and, for that matter not necessarily accurate. In fact, *The Times* of 21 August 1975 acknowledged that "the work of some polytechnic departments more nearly satisfies the category of excellence than that of some university departments."

The polytechnics were created by combining smaller institutions of learning, following Government action in 1966. Unlike universities, which receive operating funds directly from the central Government, polytechnics are tied much closer to local communities and receive the major portion of their funding through local authorities.

Undergraduate study in a university is a full-time endeavor. While this is generally also the case for polytechnics, one also finds courses in which students work toward a degree while attending only part-time (although a one-course-at-a-time program is generally not possible).

As pointed out in the earlier article, research funding for the polytechnics has been somewhat of a Gordian knot: The Science Research Council (SRC) funding committees, i.e., the representatives of the Government, feel that a demonstrated research capability of university standard is a prerequisite to funding, but without financial support no research capability can be developed!

During my visit to the Polytechnic of Central London (PCL) I learned that it was formed by the union of two institutions: The Polytechnic, Regent Street, and the Holborn College of Law, Languages and Commerce. The former originated in 1838 as a scientific educational institution, changed character

about forty years later, and eventually assumed the four-fold purpose of providing spiritual, intellectual, physical, and social activities. The other institute was formed in 1958, again by the amalgamation of two earlier institutes. With the merger with a college of education, PCL arrived at its present strength in 1975. There are now eight schools: Communication, Education, Engineering and Science, Environment, Languages, Law, Management Studies, and Social Sciences and Business Studies.

General direction of the affairs of PCL is by a Court of Governors, which comprises members from outside PCL, the top administrators of PCL (Rector and Senior Pro-Rector), six members of the Academic Staff, and two students. Responsibility for academic matters rest with an Academic Council, composed of representatives from the various faculties.

It seems that there is an intended social distinction made between universities and polytechnics. The faculty registers of University College, London and of the University of Leeds, just to cite two examples, list Professors, Readers, Senior Lecturers, Lecturers, etc. There is no listing of Professor in the faculty register of PCL; only Readers, Principal Lecturers, Senior Lecturers, Lecturers, etc. There are administrators, of course. But these have titles such as Head, Dean, and Sub-Dean. In the School of Engineering and Science at PCL all administrators are elected by the Faculty. Degrees are not awarded by PCL or any other polytechnic directly, but by a larger body, CNAA, the Council for National Academic Awards. (Universities, on the other hand, award their own degrees.)

It was of interest to me to find that PCL offers the services found in American Universities: Library, Careers Advisory Service, residence halls, Student Health Service, Psychological and Social Counseling, sports facilities, and a day nursery. Unlike public universities in the US, PCL also has a chaplain, who "is happy to meet all members of PCL regardless of creed or denomination." A Students' Union, that appears to be organized and run completely by the students, is the center of all kinds of extra-curricular activities.

The administration operates a Computer Centre, which is equipped with an ICL 19025 computer and a PDP-10 system with terminals distributed throughout PCL.

One item of special interest to Americans is the American Studies Resources Centre, established with the aid of a grant from the US Government, with visiting professors from the US under the auspices of a Fulbright award.

As is the case for university students, individuals who are legal residents of the UK are eligible to apply for educational grants from their local authority. This means that not only is tuition free, but that the student also gets a cost-of-living support grant while attending an institution of higher learning. (Since funds of a locality are limited, academic competence factors into the grant obtained. The actual amount contributed by the grantor also depends on the financial circumstances of the student.) This support, plus tradition, are probably the reasons that attending a university on a one-course-at-a-time basis is not possible.

One would think that under this support system most of the available space in an institution would be occupied by British students—especially in a field such as Engineering. The actual situation is quite the contrary, according to my hosts at PCL. While a large majority of the students at PCL studying such traditionally prestigious subjects as the classics are said to be British, 80% of the 400 full-time undergraduates in Engineering are foreigners.

In addition to the usual three-year Engineering program which results in a BSc, PCL also offers a so-called Sandwich Course, at present only in Mechanical Engineering, which results in a Higher National Diploma (HDN). Here a student attends college full time for a year, works in industry for a year, then returns for a final year of academic training. In many cases students attending here are fully financed by their employers. Several HDN programs of various lengths in other disciplines are also offered.

Whereas undergraduates in Engineering at PCL are principally foreigners, most graduate students are British and work in industry or on funded research projects. Again there are two Master's programs here. The MSc program, which comprises around 80 students, requires two years of course work (one day plus one evening per week), with a project and thesis to be performed during the second year. Fees are very low (£34.00. plus £44.00 CNAA registration fee.) The M. Phil. program, comprising about 25 students, requires very little course

work. My hosts did not elaborate on details of this program.

There are also several postgraduate diploma programs of shorter duration than the Master's programs. A PhD program requiring more research (but no additional formal courses) is also offered, but it appears to be still a rarity at PCL.

Although, as stated above, research funds appear more difficult to obtain than at a university, a number of research projects in the School of Engineering and Science are in progress. Among these we find:

(1) Bio-medical Research: This covers a wide range of activities, including radiation dosimetry, the study of radiation damage, effects of x-rays on mechanical properties of bone, mechanical properties of skin, ultrasonic bioacoustics, circadian rhythms, short-term memory mechanisms, and others. Support is from the Medical Research Council (MRC) and other sources of medical funds.

(2) Bio-Organic Research: Includes work on industrial micro-organisms with respect to antibiotics and the utilization of hydrocarbons; skin microbiology; mutogenesis; immunology and the entry of drugs in mammalian cell culture. Projects are supported by both the MRC and the SRC, a drug firm (British Petroleum Research Ltd), and others.

(3) Applied Ecology: In conjunction with the Thames Water Authority, the organization responsible for London's water supply, various studies related to reservoir management are in progress. This, for example, includes a study of filter feeding zooplankton and of zooplanktonic prey selection by reservoir fish. In the biometrical and botanical area, a field project is concerned with the relationship of existing vegetation to environmental parameters and past management practices. Some other work deals with the use of computers in taxonomic data-handling. Among the projects in microbial ecology, work is being carried out with the British Antarctic Survey on nematophagus fungi and the nematodes from Antarctic moss and soil samples, together with separate feasibility studies concerning fungal pathogens of animal parasitic nematodes. In work dealing with pollution, one of the studies in progress deals with the effects of run-off from roads and vehicles on aquatic and terrestrial ecosystems. Another one focuses on the effects of heavy metals in the food chain of a marine environment.

(4) Spectroscopy: With considerable financial support from SRC and active collaboration with the National Physical Laboratory, other research organizations, and industry, this team is investigating both theoretically and experimentally the physical properties of materials. Experimental techniques include much modern computer-based technology.

(5) Vacuum and Surface Science: Research involves studies on gas-solid interactions, field emission microscopy, and other work. This work also enjoys SRC support and active collaboration with other research laboratories.

(6) Dynamics and Acoustics research: Deals extensively with computer analysis of vibrating systems, effective methods of noise reduction, and acoustic filtering. It has also involved real-time holography, for such applications as turbine blade measurement. In addition to SRC funding there is close collaboration with and support from industry.

(7) Manufacturing Systems Research: This group is concerned with using systems-approach techniques for developing optimum manufacturing procedures of discrete mechanical components.

(8) Real-Time Computer Research: With support from the SRC, NATO and others, this group looks at the underlying technologies of systems in which a computer forms an essential part. Some examples are design of variable topology multi-computer systems, control and optimization strategies for computer-monitored energy systems, and application of graph theory to real-time systems.

(9) Signal Processing Research Group: Dr. Gerald D. Cain, Principal Lecturer and the Project Director of this group, and Mr. Richard C.S. Morling, Associate Project Director, were my hosts for the PCL visit. They told me of their success in educating engineers in techniques of mini- and microcomputer technology and in digital signal processing with a number of "Short Courses," both in London and in Florence, Italy. These courses "put them on the map," for, indeed, Cain is well known in several of the Universities that I have called on since the PCL visit.

The Signal Processing Group, in addition to Cain and Morling, currently comprises two research officers (this is the British way of referring to pro-

fessional staff members), three technicians, one research fellow, and three research assistants. Funding is of a level of £50,000 annually sponsored by the SRC, the Royal Aircraft Establishment, NATO, and various industrial firms. In addition, there are a number of final year undergraduate projects, which are considered a very important part of training at PCL.

The activities of the group cover a broad range of digital instrumentation applications, emphasizing interfacing systems, data communication systems, and digital signal processing techniques for use in a variety of industrial, biomedical, and educational applications. The major program at present, carried out in collaboration with the Istituto di Automatica of the University of Bologna (Italy), is Project MININET. This is a small-scale data communication network based on packet-switching techniques, which has as its objective the interconnection of a heterogeneous assortment of laboratory monitoring and control devices, data acquisition equipment, and small minicomputer installations. While ARPANET pioneered large-scale network developments in the late 1960s, surprisingly enough, according to Cain, the technique has not been adapted to small-scale systems.

A typical user-remote connection serviced by MININET would be an analog measurement transducer feeding an A/D converter, the digital output of which is dispatched to a remote minicomputer that digests the data and decides on a suitable control signal. This control is issued back to the user's location, where a D/A converter actuates the local controller. Clearly, such a communication system would be useful in many laboratory/industrial instrumentation and control environments.

Other projects of the group deal with low-cost interface development, process control applications of microcomputers, computer-aided digital filter design, adaptive transversal filters using charge-coupled devices, and development of a digital receiver for the OMEGA worldwide navigation system.

Clearly, Cain and a number of his colleagues have shown it is possible to make valuable research contributions in polytechnics, if the researcher has the initiative to seek support and to adapt his program to fit societal needs. (Irving Kaufman)

FLUID MECHANICS

FLUID MECHANICS RESEARCH AT THE BROWN-BOVERI COMPANY LTD. CORPORATE LABORATORIES AT DÄTTWIL

Brown-Boveri Company Ltd., a multinational corporation based in Baden, Switzerland, is engaged in worldwide power generation, transmission, distribution, conversion, and utilization equipment manufacturing as well as the supply and manufacture of various types of industrial electronic equipment. The company has a turnover of approximately $5 billion a year, of which 8% is spent on R&D. The R&D activities involve some 6000 personnel. Research is carried out on three levels: Besides the corporate research laboratories located near Baden in Dättwil, which account for 5% of the R&D budget, there are the central laboratories of the German, Swiss, and French national companies, and the divisional testing development and design departments of the line units of the three national companies. Although there is considerable overlap of the activities of all, the corporate labs tend more toward the basic sciences and the divisional labs more toward product design. The director of corporate research of Brown-Boveri in Dättwil, Prof. Dr. A.P. Speiser, explained the corporate structure and the structure of research at the various laboratories as previously stated.

The leader of the fluid mechanics research group at the corporate labs is Dr. M.E. Escudier, who completed his studies for the doctorate of Mechanical Engineering at Imperial College of Science and Technology, London, and came to Brown-Boveri in Dättwil some six years ago via the US. Escudier was originally hired by Brown-Boveri for research in plasma physics. Some five years ago, however, he started the fluid mechanics research group and has since remained with it. With Escudier, I met Dr. J. Bornstein, who received his PhD from the Polytechnic Institute of Brooklyn, and Dr. J.J. Keller, who received his PhD at the Swiss Federal Institute of Technology in Zurich.

Escudier presented some of the details of flow studies concerning confined vortices in straight and ring tubes. The motivation for such studies is the need for the proper design of the toroidally-shaped inlet and exit cham-

bers for axial flow turbo machinery. It is the purpose of such chambers to distribute the flow uniformly tangentially to the inlet stage of turbomachinery and to gather the flow efficiently in a uniform manner from the outlet stage of such turbomachinery. The flow into and out of the turbomachinery causes standing vortex flows in these doughnut chambers, and it is the properties of these vortices that are being studied in detail. The flow proceeds into and out of the toroidal chambers for entrance and exit flows, respectively, through radially oriented ducts. The laboratory setup that I saw for the investigation of such flows consisted of clear plastic models supplied with water as the working fluid. The properties of the flow field are studied either by flow visualization techniques or laser Doppler velocimetry. In some cases the toroidal vortices are so strong that their cores cavitate and are clearly visible. For the case of exit flows, curiously, there is a standing wave pattern in the core of the ring vortices, the wavelength of which becomes shorter as the radial exit is approached.

In order to preserve the essence of the entrance and exit chamber problem and yet simplify it in some respects, Escudier fashioned a straight cylindrical tube with distributed tangential inflow (somewhat in the manner of a Hilsch tube) and with outflow through a cylindrical tube coaxial with the vortex tube and located at one end of it. The other end of the vortex tube was closed. The flow in the vortex tube was then studied as a function of the ratio of the diameter of the exit tube to the diameter of the vortex tube. An unexpected result is that the axial component of flow into the vortex tube contains a velocity defect in the core which tends to disappear when exit tubes of diameter considerably smaller than that of the vortex tube are used. In the case of the toroidal vortex tube, two vortices from the doughnut vortex tube enter the exit tube and lose their identity in a very short distance. This cancellation may be caused by a violent Crowe-type instability of the vortex pair.

A serious problem that arises in hydraulic machinery in general and throttling valves in particular involves flow excited acoustic resonances. Keller has studied such flows from both theoretical and experimental points of view. Such resonances can occur when there is a high speed flow in a duct and the duct communicates with an adjacent acoustic chamber. Keller has explained such behavior on the basis of an oscillation of the interface between the flow in the duct and the acoustic chamber and some of the high-speed flow in the duct therefore impinging periodically on a wall of the acoustic chamber. The pressure oscillation in conjunction with the oscillating interface moves into and out of the acoustic chamber, and the pressure wave caused by the high speed flow periodically impinging on a wall of the acoustic chamber serves to reinforce the pressure wave. Under certain circumstances pressure oscillation amplitudes of the same order of magnitude as the stagnation pressure of the high speed flow in the duct have been observed. Keller has found that such undesirable flow behavior can be minimized by proper design of equipment.

The Brown-Boveri Corporation has been engaged in R&D of a device known as the Comprex for many years, and to my knowledge it is the only company that is doing so. The Comprex is a wave-type compressor that can be used to supercharge internal combustion engines or in connection with a high pressure gas turbine installation. It consists of peripheral passages oriented in an essentially axial direction on a long cylindrical rotor with porting that admits hot exhaust gases into and out of one side of the rotor and cool gases to be compressed into and out of the other side of the rotor. The wave phenomenon that takes place between the two gases when they are exposed to each other in a dynamical situation serves to compress the cool gas and expand the hot gas in a reasonably efficient manner. Since the Comprex is a wave-type device, it is intended to be used at or near resonance conditions. Keller is now performing a theoretical analysis of resonant and off-resonant operation of the Comprex and its part load capability. It has already been utilized experimentally to supercharge a diesel engine in a truck, and it is felt that soon the state of development of the device will permit its being marketed.

The corporate research center of Brown-Boveri Ltd. is one of the most beautiful centers of its kind that I have ever seen. Neither effort nor expense

have been spared to provide a facility with a university-like atmosphere and the best equipment available in order to encourage the generation and development of ideas for the corporation. The pursuit and final successful development of an elegant, yet difficult device such as the Comprex speaks well of corporate attitude and direction. (Martin Lessen)

HYDROMECHANICS RESEARCH AT THE SWISS FEDERAL INSTITUTE OF TECHNOLOGY (ETH), ZURICH

Located on the beautiful new campus of the Swiss Federal Institute of Technology (Eidgenössische Technische Hochschule, or ETH) in Hönggerberg, near Zurich, is the Institute of Hydromechanics and Water Resources of the Dept. of Civil Engineering. The Institute has two chairs: Professor T. Dracos occupies the Chair in Hydromechanics, while Prof. E. Trüeb is the incumbent of the Chair in Water Resources. My visit was confined to the Hydromechanics activity. The professional staff in the Hydromechanics Division consists of Drs. A. Gyr, A. Müller, and J. Bühler, whose research activities focus on sediment transport, mixing and ground water flow. The Institute has been at its new quarters two years. During that period much in the way of new equipment has been acquired, and the research program now is well underway.

Some idea of the state of affairs of academe in Switzerland can be gleaned from the fact that professorial salary levels vary from SwF 60,000 per year for junior professors to SwF 120,000 per year for senior professors; at approximately $1.00 = SwF 1.60, the equivalent salary range in dollars is $37,500 to $75,000. (However, the cost of living in Switzerland is approximately 50% more than that in the US.)

Support for the research program of the Institute is provided principally by the Swiss Confederation, from which the Hydromechanics Chair receives SwF 50,000 per year for unspecified research. It also receives roughly SwF 400,000 per year of project funding from the ETH and the Swiss National Science Foundation. This funding, which is exclusive of the salaries of the professorial and professional staff personnel, graduate student support, and large capital equipment, (all provided by the ETH) goes toward providing additional technical and technician staff as well as noncapital equipment and supplies. Dracos noted that at present the Institute does not have enough shop and electronic technicians for the research program and is therefore forced to farm out some of the equipment design and fabrication work that, under other circumstances, could be done in-house. Besides its involvement in basic and applied research, the chair also supplies undergraduate and graduate instruction in Hydromechanics.

Since a good part of the research effort in hydromechanics involves turbulent flows in rivers and flumes, a great deal of research is in progress on the properties of naturally occurring turbulence; it is hoped that this effort will culminate in a predictive theory. Thus there has been and is continuing much experimental work in rivers in order to obtain mean velocity profiles, turbulence intensity, spectra, and Taylor microscale. It has been found that there is no isotropy in the properties of the turbulence in the cross-stream direction to the flow. It has also been found that there is much greater intensity of turbulence in channel-type flows for the same relative roughness on the bottom as for flow in a pipe with similar roughness. Turbulence structures or bursts to the surface in river flow can be easily identified because of the concomittant large sediment transports from the bottom, thus enabling the utilization of conditional sampling techniques. In the laboratory such flows are being studied in a tilting flume of dimensions 60 cm wide × 40 cm deep × 25 m long. The slope of the flume can be varied from 0 to 2%. There is an installation to introduce sediment into the flow and to remove it at the end of the channel automatically. The foregoing, along with precise control of the temperature of the water, makes possible the study of the bottom boundary layer in the flume. Flow observation equipment consists of a coordinate table for velocity measurement using two-channel laser Doppler anemometry along with hot film anemometers and a hot wire x-probe. The laser Doppler anemometer is used to observe the velocity between the probe wires, and in this manner three components of turbulent velocity can be obtained. Differential bottom roughness

in longitudinal bands is used in a study of induced secondary motions of the flow. Another channel 90 cm wide × 120 cm deep × 20 m long is used to study buoyant jets and plumes in water, with applications to pollution transport and dispersion. In the area of ground water flow, unsaturated seepage flow conditions including infiltration and propagation through to a water table are being studied in a ground water flow facility. The analytic solution for seepage flows under homogeneous isotropic conditions are known. However, experimental research is underway for layered soils in the ground water laboratory. The soil density is measured by gamma-ray attenuation.

The Hydromechnics Division of the Institute has two PDP-11 computers; one is used for data processing and the other is used for analog to digital conversion. There is also an interface with the Swiss Federal Institute of Technology Computing Center at Zurich. In all, I was very favorably impressed with the enthusiasm, program, and equipment of the Hydromechanics Division of the Institute and the direction given to its program by Professor Dracos. (Martin Lessen)

MATERIAL SCIENCES

CORROSION RESEARCH AT ADMIRALTY MARINE TECHNOLOGY ESTABLISHMENT (AMTE)

In November 1977 the Admiralty Materials Laboratory, Holton Heath, Poole, Dorset, was combined with several related UK Ministry of Defence (MOD) activities to form the Admiralty Marine Technology Establishment (AMTE). This note results from a recent visit to the wooded setting and the Establishment, where my host was Mr. Don Birchon, Materials Engineering Advisor.

Materials research at AMTE (Holton Heath) is divided into three divisions: Metallurgy and Ceramics, Chemistry and Materials Engineering, and Chemical Technology. As is the case at other MOD labs, such as the Royal Aircraft Establishment and the Royal Armament Research & Development Establishment where materials research has been reviewed in recent *ESN*s, (*ESN* 32-11:381 & 33-1:6) the organization chart doesn't reflect classical scientific disiplines. Rather, the research divisions seem to be comprised on the basis of historical evolution, available personnel, and the needs of the moment. One difference between Holton Heath and the other labs mentioned above is that it is dedicated almost entirely to materials research, whereas the others involve a much wider spectrum of engineering, science and technology.

My visit to Holton Heath covered several research areas, including corrosion, development of high strength naval steels, ceramics, nondestructive analysis, and storage batteries. This note will concentrate on its research program on marine corrosion problems, including flow effects in seawater systems, bimetallic corrosion, environmental cracking, and "hot corrosion" in marine gas turbines. Corrosion research is carried out in the Metallurgy and Ceramics Division, headed by Mr. J.F.G. Conde. This division has three main sections: Corrosion, Ferrous and Nonferrous Metallurgy, and Ceramics. The redundancy in the division and section titles actually reflects the cooperation and overlap between the various groups.

Marine corrosion researchers have several excellent large-scale test facilities at their disposal, particularly for seawater flow experimentation. Mr. Brian Angell gave me a tour of the facilities at the Holton Heath site. In addition to these, the lab also makes use of a "once-through" test facility situated about 40 km away at Portland Harbour near Weymouth. The Holton Heath facilities comprise 6 separate systems, each of which includes a 2000-gallon seawater supply tank and one or more pumps for circulating purposes. Various plumbing arrangements are possible so that different types of flow experiments can be conducted. The main distinction between the test facilities here and those at the laboratory's outstation on the Portland Harbour breakwater is that the former relies on seawater brought by tank truck from Weymouth, while the latter uses water drawn directly from the Harbour. In spite of the fact that AMTE is only several hundred yards from the upper reaches of Poole Harbour, the water there is excessively diluted by freshwater outfalls, therefore a 60,000-gallon stock of transported seawater is carefully maintained at Holton Heath, with 4000 gallons replenished each day.

All aspects of corrosion in seawater circulating systems are of interest, but the emphasis is on standard piping and valve materials such as 90/10 cupronickel and Ni-Al bronze. These are studied with particular attention to alloy compositional and processing variables and their effects on corrosion behavior and mechanical properties. For example, the effect of various heat treatments on the corrosion behavior of cast Ni-Al bronze is being studied with a microstructure-properties approach. One of the excellent circulating systems to simulate seawater flow conditions is used in this program. Alternative alloys such as cast Cu-Ni, Cu-Fe and titanium alloys are also being studied, and fracture, weldability and elevated temperature mechanical properties are also being investigated for this application.

Bimetallic corrosion is being given considerable attention both from the theoretical standpoint and in terms of experiments. Zero resistance ammetry is being used to evaluate literally thousands of couple/environment situations in aerated flowing seawater, including the effect of anode-to-cathode surface area ratio and the geometric arrangement. This may sound like grass-roots corrosion research, and indeed the data has great practical value for designers. However, the information gained from the experiments assists in the development of throwing power equations for common geometries (e.g., tube-to-plate and crevice situations). J.C. Rowlands, working with D.J. Astley (Imperial Metal Industries, Birmingham) has been developing equations for the calculation of throwing power distances and corrosion rates in these various cases. These equations are intended to enable designers to predict the extent and magnitude of bimetallic corrosion in the marine environment. The equations have been applied in such situations as heat exchanger tubes, pipe-to-tank, pipe-to-pipe, etc. The work is unique in that it is an attempt to estimate throwing effects quantitatively in dissimilar metal systems.

Another applications area where bimetallic corrosion is a prime concern is couplings. An experimental program is being conducted to evaluate the corrosion performance of couplings of all kinds, particularly in chloride-contaminated high-pressure air and hydraulic systems. One of the workers in this area, Ann J. Edwards, described the results obtained for various copper-base alloy pipes and couplings, as well as for Ti-Ni alloy ("Cryofit" shape-memory-effect) couplings on copper alloy pipes. Most of the coupled metals under study are well-enough matched that severe galvanic corrosion is not experienced, but there are significant effects, particularly for O-ring type couplings where crevice situations can develop. Welded assemblies or the shape-memory-effect couplings are much preferred. The Ni-Ti couplings are just a bit more noble than 70-30 cupronickel, which leads to only slightly greater attack on the pipes adjacent to the couplings. The work on this problem is of a very practical nature, emphasizing carefully controlled corrosion exposures and the development of accurate quantitative and qualitative data.

Flow effects on corrosion are being analyzed in a quite sophisticated fashion by Rowlands and coworkers at AMTE in a joint program with the Univ. of Southampton. The relationships between impingement corrosion current and parameters of fluid flow (*viz.*, wall shear stress and turbulent velocity as determined by hot wire anemometry using air models) are under study. For example, the corrosion profile associated with heat exchanger tube inlets of various radii, predicted by measurement of rms turbulent velocity (sometimes called the "turbulence intensity") from the air model, is correlated with actual sea water tests on copper tubes. Also, impingement corrosion of a copper disc subjected to a submerged jet of seawater is compared with fluid flow characterization made in a separate air model. Work on another fluid flow-related corrosion problem, cavitation damage, is also being studied with the assistance of the group at Southampton. The aim is to study the relation between cavitation damage and measurable noise in a cavitation flow system. The correlation between pitting rate and sound pressure level is being measured experimentally and empirical laws are being developed.

Corrosion monitoring, i.e., the detection and measurement of corrosion in an operating system, is of great interest. The work is not simply the application of standard laboratory corrosion rate methods, such as polarization resistance and linear polarization, but also the development of new techniques to monitor corrosion in marine environ-

ments, assess corrosion damage, and locate the sites of corrosion. Various techniques have been or are being developed for corrosion monitoring in operating systems, including the "AMTE corrosion meter" which is available commercially, an "AMTE cavitation monitor," and various other schemes. In addition to the development of these methods aimed at practical application in service situations, work is conducted on more basic aspects of the monitoring of corrosion processes, such as impedance analysis. Investigation in the general area of corrosion monitoring is being done in cooperation with the National Corrosion Service (see *ESN* 32:10-349) as part of a comprehensive UK program aimed at reducing the costs of corrosion in UK industry.

Environmental cracking in the marine environment is another area receiving considerable effort. Several classes of materials are under study, including copper-base marine alloys, stainless steels (particularly in elevated-temperature, ~250°C, waters), and high strength (HY-type) naval steels. Basic research support for AMTE's interest in corrosion fatigue and stress corrosion of HY steels is provided by several extramural contractors, including Newcastle upon Tyne Univ., The Welding Institute, and Fulmer Research Institute. The cooperative work with Newcastle and Fulmer involves the study of strain rate, pH and potential effects on crack extension under stress corrosion (static tensile loading), and high-strain low-cycle corrosion fatigue conditions. These studies also include the evaluation of the effect of various welding methods. This work is aimed at isolating the key metallurgical parameters that control corrosion fatigue behavior. For example, experiments are underway on steels with a range of work hardening characteristics, thereby promoting different plastic zone sizes at the crack tip. Thus the classical explanation of fracture toughness, that metals which generate large plastic zones absorb more energy and so are tougher, can be evaluated. In complementary work at The Welding Institute, the influence of biaxial stressing on crack propagation rate in HY80 and HY130 steel is being studied under cyclic loading conditions in air and synthetic seawater environments. Crack growth is monitored using a DC potential difference method which has been developed.

Salt-accelerated gas turbine blade corrosion ("hot corrosion") is also being studied, with extramural support from Newcastle Univ., Imperial College of Science and Technology, Cranfield Institute of Technology, and Liverpool Univ. The program at AMTE includes the operation of high pressure burner rigs to study the behavior of new blade alloys and protective coatings. M-Cr-Al-Y-alloys and protective coatings are being developed by Liverpool Univ., and the effect of alloying additions, including rare earths, is being studied in cooperation with Newcastle. Mechanisms of "hot corrosion" are being studied in detail, particularly in the extramural programs. The work at Imperial includes the application of a number of sophisticated techniques to gain greater knowledge of the electrochemistry of "hot corrosion." Several fundamental aspects are being examined, including electrochemical potentials, crevice effects, and galvanic couples. Studies of vapor pressure relations in molten salt solutions using time-of-flight-mass spectrometry have shown previously unsuspected features such as the generation of HCl and SO_2 from NaCl and Na_2SO_4, as well as other volatile species. This work may have considerable significance in characterizing the mysterious mechanisms of hot corrosion attack.

In summary, the AMTE (Holton Heath) corrosion research program is aimed directly at solving existing naval engineering problems. The facilities available are extremely well designed and maintained and provide outstanding opportunities for both data generation and the development or proving of theoretical models for corrosion processes. The work emphasizes those modes of corrosion that prevail in naval sea systems, and only the appropriate materials of use are studied. There is not particularly hot pursuit of corrosion mechanisms at AMTE *per se*, but there is clear recognition of the importance of this aspect, as evidenced by the complementary extramural programs at various universities and institutes. (Jeff Perkins)

MEDICINE

THORACIC SOCIETY SPRING MEETING (1979)

The Thoracic Society founded in 1944 is a new organization by British standards. It consists largely of internists, physiologists, and relatively few surgeons and radiologists, who share a common interest in diseases of the chest. As membership is not limited to British physicians and surgeons, there is a sizable overseas contingent. The current meeting (1-2 February 1979) was held in conjunction with the American Thoracic Society. A combined meeting of these two groups is held in the alternate country every two years.

The ancient and honorable Royal College of Physicians, the site of the meeting, is housed in a modern building on the southeast corner of London's Regent's Park. The interior architecture is dominated by a three-tiered spiral staircase with portraits of many famous British physicians and surgeons of past centuries on the walls. The library is large and contains thousands of priceless ancient volumes dealing with botany, zoology, and the early practice of medicine. The ancient and the modern are very tastefully combined, and the entire effect of the building and its contents is an exceptionally pleasing one.

The Royal College was founded out of necessity early in the 16th century. (The precise date is 23 September 1518.) In the centuries prior to its founding, medicine was practiced by four groups: Physicians, barber-surgeons, apothecaries, and quacks. The physicians were those with university degrees, well versed in Latin and entirely literate. Surgery was quite primitive, generally carried out by barbers, and apothecaries both prepared prescriptions written by physicians and practiced on their own. The last group dealt mostly in magic and in the ancient primitive remedies. In 1421 the English Parliament petitioned King Henry V, asking that all except university graduates be excluded from the practice of medicine. These recommendations were accepted but, to our knowledge, never implemented. An act of Parliament in 1511 limited medical practice to those who had undergone a strict examination, and seven years later the Royal College was founded. The adjective, Royal, in no way signifies that the College is an organ of the state or Crown or that its activities are controlled by either body. The title is purely honorific, a mark of status, that orginates from its creation by the granting of a royal charter. Although Henry VIII was the nominal founder, much credit must be given to Thomas Linacre, the leader of the physicians at that time. As the first president he was given the power to fine and imprison those who practiced medicine without adequate qualifications. The first charter gave as the objectives of the College: "To withstand in good time the attempts of the wicked, and to curb the audacity of those wicked men who shall profess medicine more for the sake of their avarice than from the assurance of any good conscience, whereby very many inconveniences may insue to the rude and credulous populace."

After a reception on the evening of 31 January, papers commenced 0915 the following morning. The first was by H.R. Matthews et al. (Queen Elizabeth Hospital, Birmingham) who reported on 17 cases of drug-induced esophageal injury. These cases had been collected by the author since 1972 and involved inflammatory injury to the esophagus by three different varieties of drugs. These were potassium, usually given in conjunction with other drugs for congestive heart failure; three antibiotics: doxycycline, tetracycline, and clindamycin; and a group of miscellaneous drugs including 5-flouro-uracil. The authors made three major points: (1) tablets tend to stay in the esophagus particularly if the patient is in the recumbent position, (2) tablets can injure the esophagus if they remain there, and (3) the esophagus may have been previously entirely normal.

The second paper was a prospective study on the immediate and late consequences of heroin-induced pulmonary edema. The cause of pulmonary edema in heroin users has been never adequately explained. There are several theories that include hypoxemia, a central nervous system effect, a direct effect on vascular endothelium, a histamine release, or a hypersensitivity reaction. The patients studied by the authors, W. Addington et al., (Cook County Hospital, Chicago, IL) had on admission a normal blood pressure, normal pulmonary venous blood gases and pressures, and a normal venous oxygen saturation. While the exact cause of the pulmonary edema is still unknown, the authors have shown it is

not related to a histamine release or a hypersensitivity reaction and is not secondary to hypoxemia or hypotension. The authors also reported on seven different patients all of whom developed bronchiectasis as a late sequela of heroin-induced pulmonary edema. The bronchiectasis in these patients is entirely unexplained.

A paper given by P.S. Burge et al. (Brompton Hospital, London) dealing with occupational asthma, rhinitis, and urticaria in a research establishment breeding locusts was characterized by the speaker's well-developed sense of humor. The workers breeding locusts were divided into four groups: Those in the laboratory—a slide was shown of a laboratory worker gingerly holding a locust; those in the field—a slide was shown of two men wandering around the open meadow; desk workers—another appropriate slide; and lastly, administrators, with a slide showing a man yawning at a swimming pool. Work-related respiratory disease was largely confined to group 1, where 28% were affected. Work-related rhinitis was more widespread, with 41% of group 1 workers affected. Positive skin test results were higher in group 1 in both atopic and nonatopic individuals. A specific IgE and IgG antibody was measured, and work-related individuals had increased IgE and IgG, while those with work-related rhinitis had increased IgG but not IgE.

A paper by P. Steiner et al. (Downstate Medical Center, NY) dealt with a negative tuberculin skin test in children with positive cultures for *M. tuberculosis*. Twenty-eight of 200 children with *M. tuberculosis* were found to be skin-test negative. Seventeen of these could be explained by an overwhelming infection, but of the remaining 11 in only two, one with leukemia and the other with sarcoidosis, was there a ready explanation. It was concluded that a small percentage of children (4.5%) with nonthreatening forms of tuberculosis may be negative tuberculin reactors without an apparent cause.

H. Gruft (New York State Department of Health, Albany) read a paper dealing with the geographical distribution of *Mycobacteria* other than *M. tuberculosis* in the eastern United States. The author and his co-workers studied a suggested geographical distribution of *Mycobacterium intracellulare* in the fresh, brackish, and ocean waters of the eastern US. Samples were collected from lakes, inland rivers, sounds, bays, and ocean waters along the eastern and Gulf coasts. Although ocean waters were rarely positive for acid-fast bacilli, those that were usually contained *M. intracellulare*. *In vitro* studies suggested that laboratory-maintained strains of *M. Intracellulare* can neither grow in the water tested nor survive for long periods. But the authors have a working hypothesis indicating that these organisms may indeed survive in the bays and estuaries studied.

A paper by J.R.M. Bateman et al. (Royal Free Hospital, London) concerned itself with tracheobronchial clearance in asthma. Airways obstruction in asthma arises from smooth muscle contraction, mucosal edema, and mucus plugging. In the past little attention has been focused on the role of mucociliary clearance and mucus plugging in asthma. The study presented was designed to assess tracheobronchial clearance of lung secretions in patients in remission from asthma and in those with mild asthma. A set of controls was established for each group. The method used in this well-executed and important paper was the inhalation of 5-μm polystyrene particles labeled with the radioactive isotope ^{99m}Tc. Lung counts were made at 30-minute intervals over the initial 6-hour period and a final count at 24 hours. The group with mild asthma showed a decreased penetration of the aerosol into the lung, as it was trapped centrally by the bronchospasm. The remission group showed no significant change when compared with its respective controls. The authors concluded that mucociliary clearance is impaired in mild asthma but normal when patients are in remission.

A paper by R.J. Knudson and M.D. Lebowitz et al. (Univ. of Arizona) physiologically compared adult PiM and PiMZ phenotypes from a random population. This paper attempted once again to clarify the controversy that exists over individuals who have heterozygous or incomplete α-1 antitrypsin deficiency. [The absence of an α spike on the serum protein electrophoretogram is indicative of a homozygous or complete deficiency of α-1 antitrypsin. The controversy concerns the incomplete penetration of the genetic trait (heterozygous), that provides a small α spike on the electrophoretogram. The homozygous deficiency

is the cause of a well-recognized airways obstructive disease. While most workers agree that individuals with the heterozygous form show no more airways obstructive disease than does the general population, there is a vocal minority in opposition.] The PiM group is a nondeficient heterozygous phenotype and is accepted by all as not related to obstructive airways disease. The authors compared these subjects with the PiMZ group, which is deficient, and found no difference (in smokers and nonsmokers) between these heterozygous phenotypes. The Univ. of Arizona study group includes 2900 subjects, 3% of whom fall in the PiMZ group.

Because of the current interest in the effects of air pollution on chronic lung disease, a report from New Guinea by H.R. Anderson (St. George's Hospital Medical School, London) was given considerable attention. This paper demonstrated restrictive as well as chronic obstructive lung disease in 46 men and 24 women native to New Guinea. The epidemiological evidence suggested that tobacco smoking was not the cause and industrial air pollution is clearly nonexistent. Exposure to domestic wood smoke could possibly be incriminated, but no conclusive evidence could be found for the cause of unexpected and rather common chronic lung disease in New Guinea.

Another paper by J. Webb et al. (Guy's Hospital, London) dealt with clinical steroid trials in patients with chronic airflow obstruction. This paper was of most interest to those who treat obstructive airways disease with steroids, as the authors determined that in their group of patients there was a mean period of 8 days for the group to reach peak expiratory flow after the onset of prednisilone. In individual patients the time taken to reach the new level did not exceed 11 days. Six of their patients, however, failed to respond.

Two good papers concerned with asbestosis were presented, the first by H. Weill and colleagues (Tulane Univ., New Orleans, LA). They studied the relationship between radiographic progression, lung function decline, and asbestosis exposure level. A cohort of 195 asbestos workers were followed for a 6-year period. Their average length of exposure to asbestos was 22 years. Of this group, 17 showed progressive parenchymal lesions and 30 showed progression of pleural lesions. Two readers independently assessed progression on a 4-point scale using paired radiographs of known sequence. Progression was assumed if one or both readers classified the film pair in a "probable" or "definite" progression category. The authors were able to relate the progression of small irregular radiographic opacities specifically to the asbestos dust effect but not to a decline in lung function. The next asbestosis paper was a proposed diagnostic classification by G.R. Epler et al. (Boston Univ. School of Medicine, Boston, MA). These authors began with several criteria: (1) history of exposure, (2) radiographic evidence of disease, (3) forced vital capacity of less than 80%, (4) single breath diffusing capacity of less than 80%, (5) fine crackling rales, and (6) breathlessness and clubbing. They determined that criterion 6 would be best eliminated and proposed that a case of asbestosis be considered "definite" if two of criteria 3, 4 or 5 as well as the radiograph were positive. They also suggested a case be considered "possible" if two of the same three criteria were present and the radiograph negative. A history of exposure to asbestos is a mandatory criterion.

A paper by K. Prowse and S. Bradbury (City Hospital, Stoke on Trent, UK) of considerable interest dealt with the dynamic collapse of large airways in chronic obstructive lung disease. Of the 124 patients studied, forty-six had dynamic airway collapse. Of the forty-six, 57% showed radiographic evidence of emphysema, while of the remaining seventy-eight only 20% demonstrated similar changes. Those forty-six with dynamic airway collapse mostly fell into the emphysema category A of Burrows and Fletcher. The results suggested that the dynamic collapse of major airways during expiration may be a more important cause of disability in patients with chronic airways obstruction than had hitherto been accepted.

The program also featured a symposium entitled "The Clinical Studies of Bronchoalveolar Lavage," chaired by Prof. Margaret Turner-Warwick (Brompton Hospital, London). The patients studied with this technique were those with predominately fibrotic or infectious lung disease. Patients with limited respiratory function or cardiac disease were elimi-

nated. A specific pulmonic lobe was selected for intubation, and normal saline was injected during a long slow inspiration. The amount of saline used was variable but fell between 120 and 550 ml. The saline was then recovered by suction, and under ordinary circumstances one-quarter to one-third was retrieved for cellular analysis. Several interesting facts were derived from this study. Macrophages were considerably increased in all smokers. The patients with fibrosing alveolitis showed no difference in total macrophage count in comparision with smoker controls. However, the eosinophile count was definitely increased and the neutrophile and lymphocyte counts slightly increased in these patients. The lymphoctes were predominately rosette formation T-cells. The response to steroid therapy was also evaluated by the lavage method. Patients were correlated by a 20% improvement in function and/or radiologic and subjective improvement. The response to therapy was variable as determined by the lavage technique, but there was generally an increase in T-cell lymphocytes. Patients with progressive disease were associated with decreased number of macrophages. Lavage also revealed that patients with cystic fibrosis demonstrated bacteria within the alveolar macrophages. These organisms were viable and showed growth in culture.

One of the last papers, by M.J. Drakeley and others, (Broadgreen Hospital, Liverpool, UK) questioned the role of surgery in oat cell (small cell) carcinoma. These authors reviewed 494 patients with this type of bronchogenic cancer, who were treated by surgery alone during the 20 years from 1951 to 1970. Of these 366 proved suitable for resection, 52 survived for more than 5 years, 19 of which for more than 15 years. After a review of the histological material, 2 of the 52 survivors were excluded as probably not having oat cell carcinoma. Of the 50 patients, 17 had positive preoperative bronchoscopic biopsies and the other 33 had peripheral tumors. Fifteen of the 50 survivors had lymph nodes containing neoplasm at the time of surgery. These statistics are certainly better than one expects from a series of patients with oat cell carcinoma regardless of the mode of therapy. In most centers of the US at this time, oat cell carcinoma is treated by chemotherapy alone, as statistics have shown that by the time the lesion in the chest is diagnosed metastic disease is usually already present. (The neoplasm may actually arise in several organs simultaneously) It is, however, hard to argue with the statistics presented as they are certainly better than expected for the treatment of this devastating disease.

The social aspect of the meeting was highlighted by a black-tie dinner held in the Osler room of the College. The food was excellent and the speeches short. The usual toasts were made, and we were entertained by six young men formerly of the famous King's College Choir, Cambridge. They sang a number of madrigals as well as English and American songs. There were two counter tenors in the group, which is unusual, and each member had to carry a wide range, but they did very well and their selections were enjoyed by all. (Irwin M. Freundlich)

MYCOBACTERIA, TYPICAL AND ATYPICAL

The genus *Mycobacterium* received considerable attention from early bacteriologists because of one notorious species, *M. tuberculosis*. Although early workers were aware that many other species of *Mycobacteria* existed, it wasn't until considerably later that a number were also recognized as pathogens. Because of efforts to isolate and identify *Mycobacteria* that were pathogenic, the taxonomy became considerably confused. The initial attempt to subdivide the genus was dependent upon a colored pigment that developed in some species in the light (photochromogens), in others in the dark as well as in the light (scotochromogens), and another group of non-pigmented members. Later, in 1959, E.H. Runyon also separated the genus into rapid and slow growers. Taxonomic order, however, was brought to the field by J.L. Stanford and J.M. Grange in an article published in *Tubercle* in 1974. Although almost five years have elapsed, acceptance of the Stanford-Grange taxonomy in the US has been slow. The reason is not entirely clear except, of course, that microbacteriological taxonomy is somewhat removed from clinical medicine. A visit to Grange's laboratory at the Brompton Hospital in London was therefore of considerable interest.

Grange claims that at least from one point of view *M. tuberculosis* is the "atypical" *Mycobacterium* as it is the only one of all the *Mycobacteria* that does not exist as a saphrophyte. The remaining great host of *Mycobacteria* exist in nature as saphrophytes with relatively few of them acting at times as pathogens. There is no common denominator of pathogenicity among the *Mycobacteria* and, furthermore, Grange believes that an attempt at classification which is in any way based on pathogenicity would be an error. Parenthetically, the reason any organism becomes a pathogen is entirely unclear. Many bacteria, pathogens and saphrophytes alike, can be found in small numbers in the respiratory and gastro-intestinal tracts of mammals under normal conditions. It is only when the mammal becomes infected that the responsible microorganism can be found in great numbers and thereby identified as being responsible for the infection. A number of factors probably play a role in infection: The virulence and number of infecting organisms that may overwhelm host defenses, a breakdown in the host's defense mechanisms, or any combination of events. It is well known that organisms that are rarely pathogenic under ordinary circumstances may indeed become so if the host is purposely immunosuppressed. These general questions can also be applied to the genus *Mycobacterium*: Why are they saphrophytes most of the time and pathogens some of the time, and why are some species never pathogenic?

In the clinical practice of pulmonary medicine tuberculosis has been a scourge over the centuries. It has been responsible for an incalculable number of deaths, and it is really only in the last quarter of a century that suitable therapy has become available. Most cases of tuberculosis respond quite well to an appropriate antibiotic regimen with relatively few resistent organisms coming to light. Some are *M. tuberculosis* but others in the resistant group, are the "atypical" *Mycobacteria*.

From a great hodge podge of species a few decades ago, the genus *Mycobacterium* is now one of the best classified of all bacterial genera. Stanford and Grange redefined the taxonomy of the *Mycobacteria* by using a single but highly discriminitive method, that of immunodiffusion analysis. They examined over a thousand strains of *Mycobacteria* by producing antigens from each strain by ultrasonic disintegration of live bacilli. These antigens were harvested from a nonantigenic medium. The results were then analysed to separate antigens common to all species, those shared between related species and those limited to individual species. In some instances a variance within a species was demonstrated with subsequent identification of subspecies. The antigens were divided into four groups: Those of group one were common to all the *Mycobacteria*; group two could be demonstrated only in slowly growing strains with antisera raised to slow growing species; those of group three were present in fast growing species alone; while group four antigens were limited to strains of individual species. In sorting out the taxonomy Stanford and Grange found that twenty separate species could be identified. While of these some could be divided into four or five subspecies, many species previously considered separate were found to be identical. The species *M. tuberculosis*, still of greatest clinical interest, is sub-divided into four subspecies; *M. tuberculosis*, *M. bovis*, *M. africanum* and *M. microti*. Others, for example, *M. intracellulare*, thought originally to be an individual species, were found by Stanford and Grange to be subspecies of *M. avium*.

The results of immunodiffusion analysis actually showed differentiation at the three different taxonomic levels, subgeneric, specific and subspecific. At the subgeneric level the *Mycobacteria* can be divided into two clusters by antigen groups two and three. This subdivision coincides with Runyon's rapid and slow growers, but both clusters contain photochromogens, scotochromogens and nonpigmented members. At the species level every strain falls clearly into one individual species. Strains with antigenic characteristics intermediate between two species were not found and probably do not exist. Serotypes within a species all contain some of the group four antigens of that species but differ among themselves by the lack of one or more of these antigens or the gain of additional group four antigens. For example, the species *M. fortuitum* has been shown to have at least five separate immunodiffusion subspecies. Grange believes that some form of mutation, probably irreversible and most probably deletional, plays an important

role in the mechanism of this intraspecific variation.

From a clinical or pathogenic point of view, the understanding of the taxonomy is critical, but on the other hand, pathogenicity itself has little if any taxonomic importance. According to Grange, the difference between a pathogen and a harmless saphrophyte may depend on very small variations between the organisms, although the result to the infected host is large indeed. Furthermore, Grange stated that to accord separate taxonomic status based on pathogenicity would undermine the scientific basis of the taxonomic classification. In addition, it is clear that a search for effective therapy for the "atypical" *Mycobacteria* also depends on a clear understanding of the taxonomy. In the development of a suitable therapy one must know which organism is causing the infection and against which organism one is developing the therapy. The importance of the taxonomy is therefore clear and cannot be underestimated. (Irwin M. Freundlich)

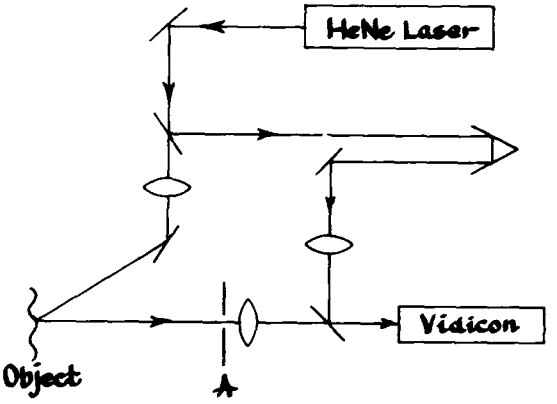
METROLOGY

STRESS/STRAIN AT LOUGHBOROUGH

The stress was in getting there and strain was the topic of the day. A heavy snowfall occurred during the morning of the Institute of Physics' meeting on Holographic, Speckle Pattern and Moiré Fringe Techniques for Strain Analysis. Sixty attendees made their way through about 4 inches of snow to the Loughborough University of Technology, in Loughborough, UK to hear 6 papers on a variety of optical techniques for strain analysis. As the author's and what appeared to be many southern Britons' snow driving experience is close to nil, the 120-mile drive from London was somewhat of a challenge.

Dr. David Rowley of the hosting Mechanical Engineering Department opened the meeting by presenting an overview of holographic interferometry and speckle pattern techniques. He stated that the wet processing, darkroom lighting and anti-vibration aspects of holography were the real "killers" of this analysis technique. He used the fact that only one paper on holography was to be presented at the meeting to support his opinion that it is not the best technique. Rowley feels that the most promising approaches to strain analysis are coherent speckle photography (CSP) and electronic speckle pattern interferometry (ESPI). In CSP two exposures (object unstressed/stressed) are made of a laser-illuminated object using a regular camera. The resultant negative contains a field of paired speckles, each of which under laser illumination behaves similarly to a pair of slits by producing a diffraction pattern. The separation of the paired speckles s is related to the observed diffraction pattern spacing d in the expected way, i.e., $s = \lambda R/d$, where λ is the laser wavelength and R the film-to-image plane separation.

The ESPI strain measurement approach, on the other hand, is shown schematically below. Here the reference beam I_r and



the image of a diffusely scattering object interfere on a vidicon's photocathode. With the aperture A adjusted so that the speckles are resolved by the vidicon, a video recording of the interference pattern of the undeformed object is made, which is then electronically subtracted from the "live" image. The image resulting from this subtraction process is in the form of interference fringes that can provide for a quantitative analysis of the out-of-plane strain.

A preproduction prototype of an ESPI system that resulted from two and one half years of development by staff members of the hosting Department was on display. The system will be produced by Loughborough Consultants Ltd. and marketed worldwide by Survey and General

Instrument Company Ltd. It is expected that production will begin within the next few months; the cost of the system is unknown at this time.

Recently, the UK Atomic Energy Authority sponsored an investigation of crack propagation in zirconium alloys subjected to reactor-like conditions. This work was reported by Dr. A.R. Luxmoore (University College, Swansee, Wales) who described the results of both moiré and speckle pattern measurements of crack opening displacement (COD). [Detailed information on moiré techniques can be found in P.S. Theocaris' book entitled *Moiré Fringes in Strain Analysis*, (Pergamon Press, New York 1969)]. Moiré pitch mismatch and rotational mismatch techniques were both used to measure CODs as small as 2×10^{-4} inches. A precision of 1×10^{-4} inches was realized when master and specimen patterns ranging from 20 to 100 lines per mm were used. Speckle patterns were also used to measure in-plane displacements (absolute) of the order 1 to 6×10^{-4} inches.

Dr. D.A. Gregory (British Aerospace) described CSP investigations of a variety of aircraft, rocket, and satellite components. Among those studied were: Wing sections and cracks on wing undersides, antenna dish displacement, gearbox displacement while vibrating, deformation under pressure of both titanium and carbon fiber spheres (for rocket motors), and bending moments of solar array booms. Gregory has measured displacements down to 0.1 μm, and he was quick to point out that the key advantage, from his viewpoint, of the speckle technique (CSP) is that it can be used in the workshop environment.

Because of a concern about static deflections of conformal gears in helicopters, an analytical/experimental investigation of a segment of the main gear wheel of a Lynx helicopter was conducted. Dr. R. Jones (Loughborough Consultants Ltd.), one of the developers of ESPI, reported on the development of a sophisticated 3-d finite element deformation model of the gear wheel segment and the verification of this model using ESPI and holographic interferometry. A finite element model consists of a finite number of elements (idealized substructures) that are interconnected at a finite number of grid points. Input data (load vectors and stiffness matrix) and output data (displacements) pertain to these element and grid points. The segment of the gear wheel was modelled using the MCS/NASTRAN finite element computer program, the development of which had taken place in the US under NASA sponsorship. The outputs of the NASTRAN program were converted into a form suitable for comparison with the experimental results. The in-plane deformation measurements were made using ESPI, and both speckle and holographic interferometry were used to determine the out-of-plane displacements. The results of the analytical/experimental comparison showed excellent qualitative agreement in that the shapes of the various displacement contours were very similar. Previous work with the finite element system has typically resulted in a stiffness that is 10-15% higher then found by experiment. Hence, the quantitative agreement, with the model being from 12-21% high, was considered to be very good. The good agreement found in this study has given the investigators a high degree of confidence in the finite element techniques as applied to gear teeth analysis.

Dr. J.M. Burch [National Physical Laboratory (NPL) Teddington, Middx], speaking on High Resolution Moiré Photography, reported the development of techniques used to examine large structures when tested to destruction, e.g., welded bridge structures. At least three innovative techniques were conceived/developed for use in testing large objects. First, the resolution of their 35mm format camera lens was increased to the acceptable level of 300 lines/mm by placing on the lens an aperture in the form of one pair of vertical slots and one pair of horizontal slots. A second benefit of aperturing was a much increased depth of focus. The problem of covering large objects with a 2-d pattern of dots was solved by covering these objects with a "wallpaper" having 22,500 dots per square inch. NPL has used the moiré technique with two cameras separated by about 1.5 m to measure out-of-plane displacements. Burch pointed out that film motion out of the focal plane would appear as an out-of-plane displacement of the object under investigation. Such film motion was eliminated by sandwiching the film between a spring loaded fused silica flat and the film carriage back. Burch also reported on the use of titanium dioxide dots, which has en-

abled NPL to make displacement measurements on high temperature objects.

The author was impressed with the large number of industrial laboratories investigating everything from tires to gyroscopes by using one or more of the optical strain analysis techniques. Perhaps the most impressive aspect of the conference was the description and demonstration of the prototype electronic speckle pattern interferometer that is soon to be purchasable. To the best of the author's knowledge, this will be the first commercially available instrument of its type.

There are two excellent references for the reader who is interested in more detail on laser speckle and its applications. The first is *Laser Speckle and Related Phenomena* (Volume 9 of *Topics in Physics*) which was edited by J.C. Dainty (Springer-Verlag, New York). This book contains a chapter entitled "Speckle Interferometry" that was written by one of the leading developers of speckle technology, A.E. Ennos. The second reference is a book edited by Robert Erf entitled *Speckle Metrology*, published this year by Academic Press, New York. (Richard S. Hughes)

OPTICAL SCIENCES

HOW THIN THE FILM

The Centre d'Etudes des Couches Minces (CECM) of the Ecole Nationale Supérieure de Physique, Domaine Universitaire de Saint-Jerome in Marseille is associated with the Centre National de la Recherche Scientifique (CNRS). This laboratory is one of the few noncommercial groups working on multilayer optical filters.

Professor P. Bousquet is in charge of the laboratory. As he was obliged to attend a Phd examination on the day I arrived, his colleague Dr. E. Pelletier took charge of my visit. The laboratory has about 10 individuals working primarily in the area of dielectric films. The work is divided into theoretical and experimental aspects of multilayer filters. They use innovative techniques in thickness control during deposition.

All of the work done here is based on interference effects produced by reflections from multiple boundaries in a stack of deposited thin films. For example, a stack of layers of alternate high and low index, each $\lambda/4$ thick, deposited on a suitable substrate form a broad-band high reflectance coating, while two such stacks separated by a $\lambda/2$ layer form a narrow-band-pass transmission filter. Other combinations can be used to produce anti-reflection, broad-band-pass, and edge filters. Layers need not be multiples of a quarter wavelength, and specifically prescribed variations in reflectance (R) and transmittance (T) as a function of wavelength (λ) can in principle be obtained with a suitable choice of indices of refraction, thicknesses, and number of layers.

Calculation of R and T for any given multilayer configuration is straightforward and can be accomplished in a few seconds by computer. However, when the problem is turned around and a specific solution is desired, the calculation of a filter configuration which will produce the desired properties is not so easy. This generally requires a fairly large number of trial computations and sequential mimimization of the function $f(\lambda) = |T_{des}(\lambda) - T_{cal}(\lambda)|$ where $T_{des}(\lambda)$ is the desired transmittance and $T_{cal}(\lambda)$ is the calculated transmittance. Usually in such syntheses, the number of layers is fixed and the indices and thicknessess of each layer are the variables. This technique requires iterative calculations and often consumes large amounts of computer time. Pelletier and J.P. Borgogno have developed a scheme for simplifying the calculations using a Fourier series approximation. They first introduce the constraint that all layers must have an optical thickness equal to some multiple of a quarter wavelength, i.e., $n_i e_i = k_i \lambda_o /4$, where n_i is the index and e_i the thickness of the ith layer while the k_i are integers and λ_o is a wavelength parameter which is not the design wavelength for the filter and can be as small as desired. Under this constraint the ratio R/T is a series of cosine terms. The desired solution is expanded as a Fourier series over a given frequency interval, and n_i and e_i are adjusted until the coefficients of both series nearly match. The CECM has demonstrated the use of this technique to design a dichroic mirror and a beamsplitter.

The laboratory has placed a significant emphasis during the last few years on the automatic correction of errors in optical thickness produced during film deposition. Such corrections are especially important for narrow-band filters which must transmit at a precise wavelength and other filters which must have a very specific $T(\lambda)$. Multilayer filters are usually made by thermal evaporation in vacuum with heat supplied by direct resistive heating or by electron beam. The thickness of the layer can be monitored during deposition by measuring the optical transmittance or reflectance at a specific wavelength. For a single quarter-wave layer, $\delta T(\lambda)/\delta e = 0$ where e is the optical thickness of the layer. It can be shown that the same condition holds for a stack of any number of layers when each layer has a quarter-wave thickness. For this reason, it is important to measure the derivative of transmission. There are two ways to monitor such a stack optically. One is to use changeable test plates located near the filter substrate and monitor single layers one at a time. The other is to monitor the stack itself. *Bousquet and his colleagues* have shown that the second method is preferable because if an error in thickness in one layer is made by overshooting, it can be partially compensated for by adjusting the thickness of the next layer so that $\delta T(\lambda)/\delta e = 0$ for the stack. Bousquet et al. have similarly investigated effects of compensated errors in layers of a Fabry-Perot narrow-band-pass filter. For example in the configuration sub-HLHLHLHL2HLHLHLHLH, an error in the 2H spacer layer would be especially detrimental as it would shift the band-pass wavelength. An overshoot of 20% in the spacer layer can be almost perfectly corrected, however, by a change in the following layer so that the configuration, sub-HLHLHLHL2.2H0.66LHLHLHLH has essentially the same characteristics as the first filter.

Pelletier and his associates are striving to automate completely the deposition for a general configuration in which layers are not necessarily a multiple of one quarter-wave thick. Instead of a monochomatic monitoring source they use a broad-band scanned spectrum, incorporate the Fourier representation discussed earlier, and strive to set the quantity $|T_{meas}(\lambda) - T_{des}(\lambda)| = 0$ for each layer, where $T_{meas}(\lambda)$ is the measured transmittance and $T_{des}(\lambda)$ the desired transmittance function. In order to accomplish this the spectrum has to be scanned rapidly compared to the deposition time for a single layer. They are now doing some experiments where the entire deposition process is automated with a minicomputer with good results.

Pelletier is making some very careful scattering measurements on multilayer films so that this loss mechanism, which is different from losses due to absorption, can be incorporated into the overall understanding of such films. It is relatively easy to incorporate absorptive losses into a multilayer model, but it has not been known how to treat scattering properly. The group hopes to develop a model that will describe the measured scattering effects which vary with angle and also produce depolarization effects. Once a single layer model is developed, it will be extended to two and more layers.

The CECM is also interested in inhomogeneous films in which the index varies throughout the thickness. This is possible by mixing varying amounts of two or more different materials having different indices of refraction during deposition. This technique can be especially useful for antireflection coatings. As part of this work a library of optical properties containing $n(\lambda)$ and $k(\lambda)$ for all materials used for thin film work including variance as a function of temperature has been developed.

This laboratory has several very well-instrumented coating plants for carrying out various kinds of thin film research. The quality of the work here is very good in both the theoretical and experimental aspects. (Vern N. Smiley)

ESN READERSHIP SURVEY

The response to our *ESN* Readership Survey questionnaire has been excellent. May we hear from those who may have forgotten to complete and mail the questionnaire?

SPACE SCIENCES

A BALLOON BARRAGE OF THE AURORAL ZONES

A research program involving the launching of 36 balloons during the period of 1-13 June 1979 is being prepared under the project management of S. Ullaland of the Univ. of Bergen in Norway. The program, known as the SBARMO-79 Campaign (Scientific Ballooning and Radiation Monitoring Organization), involves the participation of scientists from eight research institutes in six countries. Since the object of the program is to achieve a better understanding of auroral phenomena, it is not surprising to find all of the Scandinavian countries heavily involved since they possess the high latitude launch facilities for studying these phenomena. In addition to the Scandinavian countries, West Germany and Austria are also actively participating.

The scientific aim of SBARMO-79 is a further understanding of the dynamical processes in the magnetosphere. The coupling of phenomena in the outer reaches of the magnetosphere with those in the auroral-zone ionosphere is of special interest. Parameters to be measured by the balloon-carried experiments include auroral x-rays, magnetic and electric fields, VLF emissions, and atmospheric infrasonic waves. The measurements will be correlated with those made by detectors aboard the geostationary scientific satellite GEOS II which was recently placed in orbit by the European Space Agency. Specific phenomena to be investigated include the processes preceding the break-up of magnetospheric substorms, the break-up phase itself, and the redistribution of charged particles and electric and magnetic fields thereafter. These investigations are expected to result in an understanding of how magnetic substorms are triggered and how they cause abrupt changes in the conditions for charged particle propagation in the outer magnetosphere. Other phenomena of interest are related to the occurrence of sun spot cycles. Detailed investigations will be possible as to the relationship between solar flare events, substorm activity, and magnetospheric processes.

The main parameters to be measured during the balloon flights are auroral x-rays and electric fields. Three different types of payloads will be incorporated into the experiments. The first is a multi-experiment payload with equipment to measure auroral x-ray fluxes (directional and omnidirectional), electric and magnetic fields, VLF emissions, and atmospheric infrasonic waves. The auroral x-ray fluxes are measured by a 6-channel omnidirectional x-ray spectrometer and an array of 7 collimated detectors. The detectors are cylindrical NaI(Tl) crystals mounted on photomultipliers. The electric fields are measured by a pair of electric field probes and the magnetic fields by a 3-axes fluxgate magnetometer. Two orthogonal loop antennas are used to record the VLF-emissions. The acoustic waves are detected by associated temperature variations. Either 5 or 6 multi-experiments will be flown.

The second payload was designed for an optimum recording of temporal and spatial variations of the auroral x-ray flux and its energy spectrum. It contains a multi-channel omnidirectional x-ray spectrometer and an array of four collimated NaI(Tl) crystal detectors mounted on photomultipliers. It is intended to fly 10 of these special auroral x-ray payloads.

The payload for the combined measurement of omnidirectional x-ray fluxes and electric fields contains one uncollimated x-ray detector [cylindrical NaI(Tl) crystal] and 2 pairs of electric field probes in a configuration that enables the recording of 3 electric field components. There will be 21 of these combined payloads flown.

The balloons will be launched from sites in Honningsvag and Karasjok in Norway, and Sodankyla and Oulu in Finland. Telemetry stations will be operational during the entire campaign in Andenes and Bronnoysund in Norway; Husavik, Iceland; and Kap Tobin and Egedesminde in Greenland. Thus continuous reception of data will be possible as the balloons drift between all launch sites and Greenland. The balloons are to be launched when periods of sustained substorm activity can be expected or geomagnetic storms are forecast. Simultaneous flights from as many stations as possible will be launched. The expected flight times of the balloons is between 70 and 100 hours.

The various experimental groups and their responsibilities include the Technical Univ. of Graz, which will launch 9 payloads from Honningsvag for the combined measurement of omni-directional x-ray fluxes and electric fields; the Max-Planck-Institut für Aeronomie, which will launch 6 special auroral x-ray payloads and 3 payloads for the combined measurement of omni-directional x-ray fluxes and electric fields from the Sodankyla facility; the Univ. of Bergen and the Danish Space Research Institute, jointly handling the launch of 5 or 6 multi-experiment payloads and 4 special auroral x-ray payloads from Karasjok; and groups from the Univ. of Oslo and the Royal Institute of Technology, Stockholm, sharing the launching from Oulu of 6 payloads for the combined measurement of omni-directional x-ray fluxes and electric fields. Three of these will be without electric probes. The project manager will coordinate all launchings taking into account the available geophysical parameters, the situation at the launch sites, and the capabilities of the telemetry receiving stations.

Data reduction is to be accomplished through a common pool of scientists drawn from the participating groups. Each participating group is to be represented among the authors of the first five publications. An agreement between the GEOS experimenters has been reached which will permit ready correlation between satellite and balloon data. The costs of data reduction is to be divided among the participating groups with individual groups picking up the tab for their part of the payload and launch expense.

The SBARMO-79 Campaign is a year behind schedule (it was formerly known as the SBARMO-78 Campaign) owing to general funding and procurement problems. From the author's personal observation of many of the experiments, it appears the balloons will get off the ground as scheduled this summer. (Robert W. Rostron)

NEWS & NOTES

STRATOSPHERIC OZONE

An aspect of atmospheric pollution which has caught the public attention in recent years is depletion of stratospheric ozone. One effect of this depletion would be an increase in the amounts of ultraviolet light between 290 and 320 nm reaching ground level. Such light is biologically active, and prolonged exposure to it can cause skin cancer in susceptible individuals. Some new and interesting results relating to this problem were disclosed recently at a conference of the British Radio-frequency Spectroscopy Group by Prof. B.A. Thrush, FRS, of the Univ. of Cambridge, UK, who has also just published his findings in *Phil. Trans. R. Soc. London A* 290, 505-514 (1979). Using the technique of laser magnetic resonance spectroscopy in which a strong magnetic field is used to bring Zeeman components of the rotational transitions of a free radical into resonance with a far infrared laser, Thrush has obtained data which have led him to the following predictions:

1. Instead of depleting the stratosphere of ozone, the nitrogen oxides from Concorde and high-altitude subsonic aircraft such as the Boeing 747 SP that operate at altitudes up to 18 km (59,000 ft) are now predicted to enhance the ozone content slightly.
2. Release of NO and NO_2 above 20 km, which might occur from future supersonic aircraft, is still predicted to deplete ozone somewhat.
3. Ozone depletion by nitrous oxide derived from bacterial denitrification of nitrate fertilizers is expected to be less than calculated earlier. However, not enough is known about the natural N_2O cycle to predict the increase in atmospheric N_2O and therefore forecast ozone depletion caused by this source.
4. For chlorofluoromethanes and other chlorocarbons, as found in aerosol propellants and halogenated solvents, respectively, the predicted ozone depletions are 50% greater than calculated earlier by Gutowsky (National Academy of Sciences, 1976).

IEE AWARDS

On 9 March 1979, Sir James Redmond, President of the (UK) Institution of Electrical Engineers (IEE), presented Certificates for Honorary Fellowship of the IEE to Sir Eric R. Eastwood, CBE, FEng, FRS, and to Professor Sir Hermann Bondi, KCB, FRAS, FRS. Sir Eric, currently Consultant with GEC Marconi Electronics Limited, was elected for his leadership of research on radar and in the electrical and electronics industries; for his contribution to the planning and direction of scientific research on space and radio astronomy; and for his contributions to the profession. Sir Hermann, Chief Scientist of the UK Department of Energy, was honored for his leadership of space research in Europe; for his contributions to defense research and development, including particularly electronics; and, as Chief Scientist of the Department of Energy, for his leadership of the planning and execution of research and development on energy resources.

Sir James also presented the Faraday Medal to Robert N. Noyce, Chairman of Intel Corporation of America, for his inventions in the field of semiconductor integrated circuits; for his leadership of and personal contributions in teams undertaking research and development in this field; and for his leading part in the establishment of the microprocessor.

PERSONAL

Prof. Nils Jerlov, Director of the Institute of Physical Oceanography of the Univ. of Copenhagen, Denmark, has retired. He has been succeeded by Dr. Gunnar Kullenberg of the same Institution.

Prof. Pier Groen, Head of the Department of Oceanography, Petrology, and Crystallography at the Free Univ. of Amsterdam, the Netherlands, retired in March. His successor has not yet been named.

OTRAG UPDATE: QUO VADIS?

According to the *International Herald Tribune* of 3 May 1979, OTRAG, the private West German company dedicated totally to developing, manufacturing, and selling to customers regardless of political alignment, had a major setback on 27 April when the government of Zaire unilaterally renounced parts of a 20-year contract permitting 39,000 square miles of Zaire to be used as a launch facility by OTRAG. The "parts" of the contract involve all testing and launching of rockets from a facility that is virtually complete and had been used for test launches in late 1977. Technical details of the OTRAG rocket concept can be found in *ESN* 33-4:169.

ONRL REPORTS

C-1-79

FIFTH EUROPEAN SPECIALIST WORKSHOP ON MICROWAVE ACTIVE SEMICONDUCTOR DEVICES by I. Kaufman and A.K. Nedoluha

This report is a brief description of subjects discussed at a workshop attended by approximately 50 individuals engaged in work in microwave semiconductor devices and/or their use in circuits.